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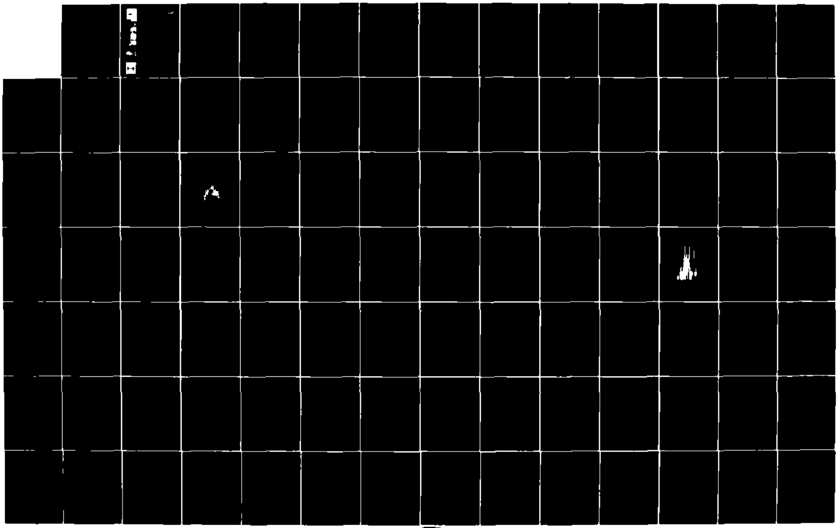

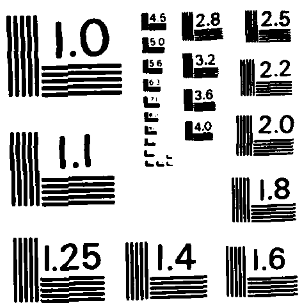
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LARGE-SCALE OPERATIONS MANAGEMENT TEST OF USE OF THE WHITE AMUR FOR CONTROL OF PROBLEM AQUATIC PLANTS

THE HERPETOFAUNA OF LAKE CONWAY: SPECIES ACCOUNTS

by

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Species accounts provided in this report summarize our knowledge of the natural history of the 30 species of amphibians and reptiles known from Lake Conway, Florida. The accounts focus on two major objectives of the Lake Conway herpetofaunal project: (1) to identify spatial and temporal changes in life-history parameters of the component species, and (2) to determine whether any observed changes were the result of the white amur aquatic plant control program. Important confounding factors influencing the ecological organization of the Lake Conway herpetofauna also were examined. ~~(Continued)~~

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20. ABSTRACT (Continued).

Quantitative annual changes in at least one of nine measured ecological parameters were detected in 17 (56.7%) of the species during the three-year study (1977-1980). Among the 30 species, ecological changes were recorded for two of four salamanders, all eight frogs, the American alligator, five of ten turtles, and one of seven snakes. Of those species in which yearly variation was observed, most showed a change in relative density (N=15), followed by seasonal activity (6), population structure (5), open water habitat use (4), food habits (4), and movement patterns (1). No yearly variation was detected in the use of specific littoral zone habitats, growth rates, or reproductive output per individual. Our ability to detect ecological changes was strongly dependent upon sample size for the species.

Ecological shifts in the herpetofauna of Lake Conway were caused by at least nine factors, grouped into four general categories: white amur, human disturbance, natural phenomena, unknown. These causative agents often were operating simultaneously, and confounded the effects of the fish. Human disturbance, through shoreline development (N=14 species), destruction or removal of individuals from the lake system (N=2), boat propeller mortality (N=3), and investigator effects (N=4), was responsible for more changes in more species than any other category: two hylid frog species were extirpated from Lake Conway as a result of shoreline development. Annual fluctuations in water level (N=5 species) and weather conditions (N=6) affected some species. Four species experienced an ecological shift in which the causative agent(s) was not identified. One higher order interaction was detected in one species.

The white amur was implicated as contributing to or directly causing distinct annual shifts in the ecology of one salamander and three turtle species. These species exhibited changes in the use of open water habitats (N=4 species), population structure (N=1), density (N=3), and food habits (N=3), which were attributable to the effects of the fish. Thus, macrophyte removal by white amur, acting in concert or perhaps synergistically with other disturbance phenomena, has caused significant ecological changes in the herpetofauna of Lake Conway.

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PREFACE

The work described in this volume was performed under Contract No. DACW39-76-C-0047 between the U. S. Army Engineer Waterways Experiment Station (WES), Vicksburg, Miss., and the University of South Florida (USF), Tampa, Fla. The work was sponsored by the U. S. Army Engineer District, Jacksonville, and by the Office, Chief of Engineers, U. S. Army, Washington, D. C. The Museum Section, U. S. Fish and Wildlife Service, Washington, D. C. 20560 provided technical assistance and personnel support for part of the radio-telemetry study of amphibians and reptiles.

This report presents species accounts from the baseline study and the first and second year post-stocking results of a Large-Scale Operations Management Test of use of the white amur for control of problem aquatic plants in Lake Conway, Florida.

Areas of primary responsibility among authors of this report were: Mr. G. Thomas Bancroft, experimental design and computer analysis; Mr. J. Steve Godley, Project Manager and author; Dr. Roy W. McDiarmid, Principal Investigator and editor; Ms. Dena T. Gross, field assistant and reproductive analysis; Ms. N. Nan Rojas, field assistant and food habits analysis; Ms. Dareth A. Sutphen, field assistant and radio-telemetry. Dr. McDiarmid is with the U. S. Fish and Wildlife Service, Museum Section, National Museum of Natural History, Washington, D. C.; Messrs. Bancroft and Godley and Mdms. Gross, Rojas, and Sutphen are with the Department of Biology, University of South Florida, Tampa, Fla.

The authors acknowledge with thanks Messrs. W. E. Ackerman and M. Lopez for help in the field, Barbara and Tom Davis for hospitality and use of a cottage as a field laboratory, Marianna B. Scott, the Secretarial Staff in the Department of Biology, USF, for help in preparing this report, and Claudia Angle for preparing some illustrations. D. Franz, D. R. Jackson, P. E. Moler, H. R. Mushinsky, and F. G. Thompson kindly provided us with unpublished data on various organisms. We also thank Dr. Earl D. McCoy, Department of Biology, USF, for generously agreeing to serve as Principal Investigator during the last two years of the study.

The work was monitored at WES in the Environmental Laboratory (EL), Dr.

John Harrison, Chief. The study was under the general supervision of Mr. B. O. Benn, Chief, Environmental Systems Division (ESD), EL, and under the direct supervision of Dr. T. D. Wright, Chief, Waterway Habitat and Monitoring Group. Mr. J. Lewis Decell was Manager, Aquatic Plant Control Research Program. Principal investigators were: Messrs. R. F. Theriot, J. D. Lunz, and E. G. Buglewicz, and Dr. A. C. Miller, all of ESD, EL.

Commanders and Directors of WES during the contract period and report preparation were COL J. L. Cannon, CE. COL Nelson P. Conover, CE, and COL Tilford C. Creel, CE. Technical Director was Mr. F. R. Brown.

This report should be cited as follows

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CONTENTS

LARGE-SCALE OPERATIONS MANAGEMENT TEST OF USE OF THE WHITE AMUR FOR CONTROL OF PROBLEM AQUATIC PLANTS

FIRST AND SECOND YEAR POST-STOCKING RESULTS

The Herpetofauna of Lake Conway, Florida: Species Accounts

PART I: INTRODUCTION

1. As producer organisms, aquatic plants are an integral component of freshwater ecosystems. Most trophic levels are dependent upon plants as an energy source, and the biological cycling of nutrients through the ecosystem is intimately tied to plant productivity. In many regions of the United States including Florida, increased nutrient loads, brought about largely by land use practices of a burgeoning human population, have resulted in a virtual explosion of aquatic plant populations. This problem is compounded by the introduction of exotic species such as waterhyacinth (Eichhornia crassipes), hydrilla (Hydrilla verticillata) and Eurasian watermilfoil (Myriophyllum brasiliense), which often out-compete native plant species and clog many of our nation's waterways.

2. Recognizing the seriousness of this problem, the U. S. Army Engineer Waterways Experiment Station (WES) in 1968 initiated research designed to control problem aquatic plants (Conover 1980). A major effort in this direction has been the development of a monosex population of white amur or grass carp (Ctenopharyngodon idella, Cyprinidae), as a biological control agent of nuisance aquatic weeds, especially Hydrilla verticillata. Realizing that successful application of white amur as a control agent required that the fish not only be cost effective but also produce no significant negative environmental impact, WES initiated in 1976 a Large-Scale Operations Management Test (LSOMT) of the fish in Lake Conway, Orange County, Florida (Addor and Theriot 1977). Lake Conway is a 743.0 ha. urban lake consisting of five interconnected pools with a known history of aquatic plant problems.

3. The LSOMT on Lake Conway included a one-year study of baseline conditions (pre-stocking) followed by approximately three years of post-stocking study. By January 1976, contracts to quantitatively monitor

specific aspects of the environment of Lake Conway had been awarded to individuals in the following agencies: Florida Department of Natural Resources (aquatic macrophytes), Florida Game and Fresh Water Fish Commission (fish, waterfowl, and aquatic mammals), Orange County Pollution Control Department (water chemistry and sediment quality), University of Florida (plankton and macroinvertebrates, nutrient budget, ecosystem response model). On 9 September 1977 a total of 7,600 white amur averaging 450 g. was introduced into Lake Conway at a density of one fish per 0.1 ha. This density, based on a stocking rate model developed by WES, was designed to achieve control of macrophyte populations on Lake Conway within four years (Addor and Theriot 1977).

4. In June of 1977 a contract to monitor the amphibian and reptile populations of Lake Conway was awarded to the University of South Florida (USF). Unlike all other contracts, this study involved a large-scale mark and recapture program to examine demographic changes in the herpetofauna. Although white amur were introduced into Lake Conway in September 1977, only three months after the herpetofaunal work began, data gathered in the 15-month period from June 1977 through September 1978, herein referred to as Study Year 1 (SY1), were of necessity considered "baseline" to which subsequent years (SY2 and SY3) were compared. Because of the late start of the herpetofaunal work, our SY1 is analogous to post-stocking year one of other studies on Lake Conway, and our periods SY2 and SY3 are equivalent to their post-stocking years two and three.

5. In addition to the herpetofaunal mark and recapture program, radiotelemetry of select species of amphibians and reptiles was initiated in September 1979 in a cooperative effort involving USF, WES, and the U. S. Fish and Wildlife Service. The herpetofaunal radiotelemetry study was designed to provide information about movement patterns and habitat usage in populations of several species that were experiencing noticeable demographic changes. This work continued through May 1982, and a report detailing these results will be issued later.

6. The herpetofaunal study on Lake Conway was designed to accomplish the following objectives:

a. to determine the species of amphibians and reptiles inhabiting Lake Conway;

b. to ascertain the habitat requirements, distribution,

ecology, and seasonal activity of each species in the the lake system;

c. to establish quantitative baseline population data for the more common or otherwise important species in each of the Lake Conway pools including density by habitat, relative age (size) structure, movements, diel and seasonal activity patterns, growth, reproduction, food habits, and related parameters as deemed feasible;

d. to monitor quantitatively, following introduction of the white amur, any changes in the species composition of each pool, movements within and between pools, density changes, or other population parameters of the amphibians and reptiles; and,

e. to determine whether any observed changes were the result, directly or indirectly, of the white amur plant control program.

7. A Baseline Studies Report (Godley et al. 1981) summarized amphibian and reptile work on Lake Conway during SY1. This report included detailed descriptions of the herpetofaunal study sites and methods, and an analysis of the temporal and spatial distributions and densities of the species during SY1. A second report (McDiarmid et al. 1983) extended these results and provided a detailed community analysis of the amphibian and reptile populations on Lake Conway during SY2 and SY3. These authors emphasized community-level changes in species composition and relative abundance patterns within and between pools. A description of new and expanded sampling procedures and methodologies, and analysis of temporal changes in habitats at the permanent herpetofaunal study sites also were presented.

8. The present report provides detailed natural history accounts for each of the amphibian and reptile species known from Lake Conway, and is intended to serve as a companion report to the community analysis. To avoid redundancy, descriptions of the herpetofaunal study sites and the detailed figures presented in McDiarmid et al. (1983) which show temporal and spatial changes in species abundance patterns on those sites are not repeated here. However, because these descriptions and figures are vital to understanding various aspects of the ecology of most herpetofaunal species, an in-hand copy of this report (McDiarmid et al. 1983) is recommended.

PART II: METHODS AND MATERIALS

9. Details of the Lake Conway herpetofaunal sampling programs are provided elsewhere (Godley et al. 1981), and only a brief update and summary of methodologies are presented here. In each pool of the Lake Conway complex one permanent shoreline site (Figure 1) was used for mark and recapture population studies; destructive samples for analyses of stomach contents and reproductive condition of selected species of amphibians and reptiles were taken from other areas of similar habitat within the lake system. A description of the permanent shoreline sites and any habitat changes that occurred at these sites during the study was provided in the community analysis report (McDiarmid et al. 1983). The deepwater transects shown in Figure 1 were discontinued after the baseline studies because of extremely low trap success per unit effort (see paragraph 7 of Godley et al. 1981).

10. In general, the herpetofaunal sampling program involved spending three days and two nights every other week on the lake so that each permanent shoreline site was censused by herp-patrols and sampled with funnel traps twice a month (see below). Alternate weeks were spent in the laboratory processing data and gathering reproductive and ecological information from the destructive samples. Brief descriptions of the major sampling methods are as follows:

Funnel Trapping

11. Funnel traps, 60x30x30 cm., were designed specifically to sample aquatic salamanders, tadpoles, small carnivorous turtles, and several species of aquatic snakes. Most funnel traps were constructed of 3 mm. black plastic Vexar netting (DuPont De Nemours & Co., Model No. 5-59-V-360-BABK) stretched over welded metal frames with funnel entrances at each end. Some wire mesh (6.35 mm. hardware cloth) funnel traps of the same dimensions were used in areas where rice rats (*Oryzomys palustris*) were common and often gnawed holes in the Vexar cover of traps.

12. During the baseline study period, funnel traps were set at each permanent shoreline site twice a month for a 24 hr. period. Traps were baited with fresh, cut fish. Because we had only half as many traps as sampling stations (N=163), the traps had to be moved to new sites each sampling trip, requiring a considerable expenditure of field time. Beginning in December

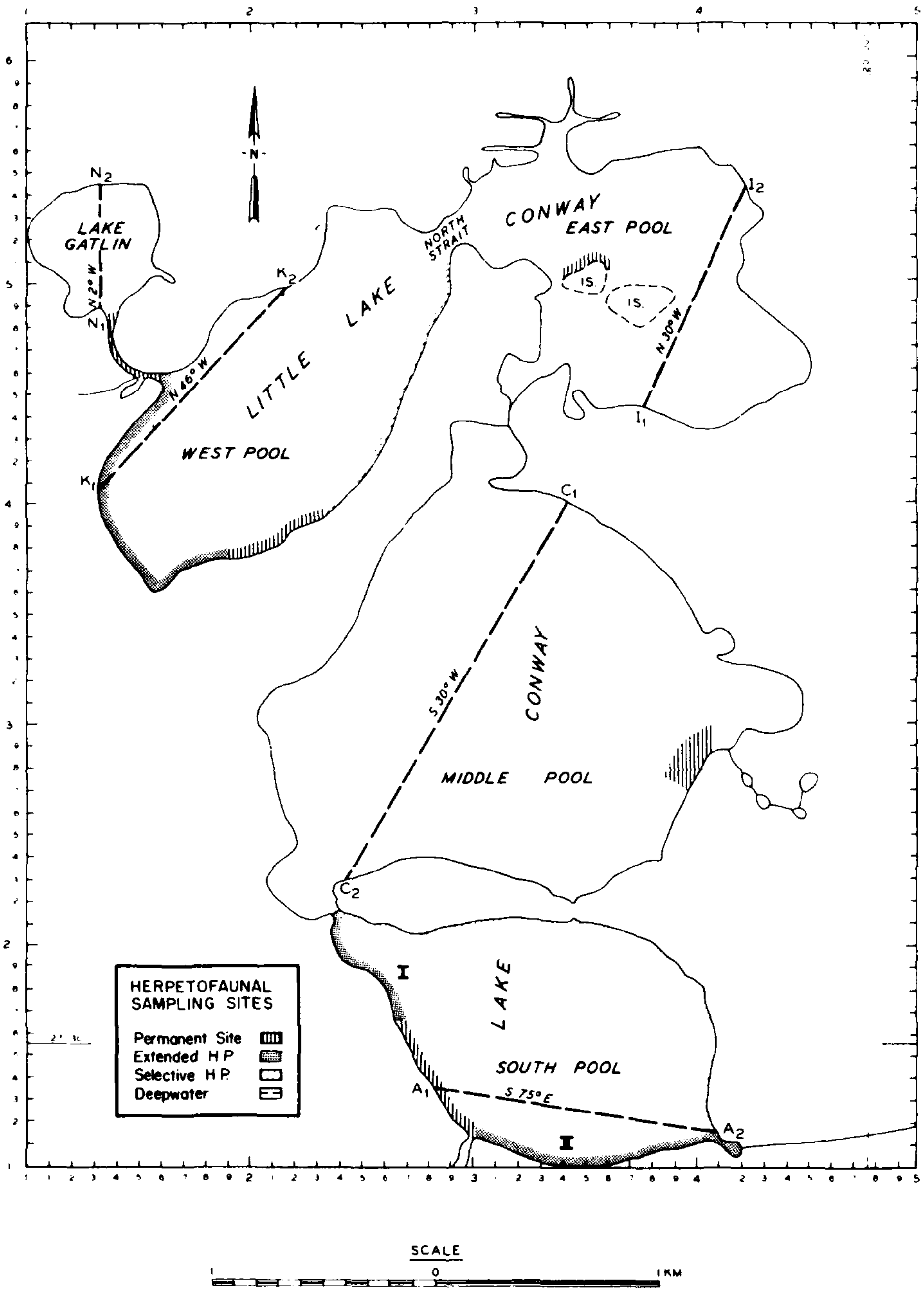

Figure 1. Map showing the five interconnecting pools of Lake Conway and the permanent sampling sites for amphibians and reptiles.

1979, funnel traps were set at each site only once a month but for a 48 hr. period. The traps were checked and freshly baited each day; animals collected on the first day were processed and usually released the same day. Thus, the total trapping effort remained constant (48 hr./month/trap station) but more field time was available for other activities. Relative density comparisons within and between sites and study years are based on total trap success per total number of trap-days (sum of all traps set per 24 hr. periods).

Herp-patrol

13. All permanent shoreline sites were censused twice a month at night from a 5.33 m. john boat. This censusing technique, termed "herp-patrol," involved the use of an electric trolling motor and two 12-volt, 120,000 candlepower spotlights. The permanent shoreline sites were censused with herp-patrols by motoring slowly along the edge of the littoral zone. One spotlight from the rear of the boat was directed towards the emergent vegetation on the shore side, while the other in the front of the boat was shined on the opposite side in adjacent, open water. A third individual collected animals with a dip net or by hand. The identification, time, location, water depth, vegetation type, substratum, activity, and behavior of all specimens observed or heard calling were recorded on standardized data sheets. All captured individuals were brought to the laboratory and sexed, measured, weighed, marked, and released at their capture point the following day.

14. In the baseline study period herp-patrols on permanent sites were replicated each sampling night with the electric trolling motor and assigned a run number of I or II. The same collecting path and direction were used on each run. The number of males of each frog species calling per 10 m. increment of shoreline was recorded on both runs; other species of amphibians and reptiles were captured and processed as reported above. First-year results indicated no significant differences in the mean number of calling frogs recorded on run I compared to run II (paired _t_ tests, Steel and Torrie 1960). However, many turtles eluded capture because of the slow speed and poor mobility of the boat when powered by the trolling motor. To improve capture success but still monitor frog populations, this herp-patrol procedure was modified slightly in subsequent years: two runs were performed each sampling

night but frogs were recorded only on the first run which was done with the electric motor, the second run was accomplished with the 25-h.p. outboard motor at slow speeds. Between-year comparisons of relative densities on permanent sites were based on the number of calling males heard only on run I (frogs only) or the total number of individuals observed per total search time for both runs (all other taxa).

Extended herp-patrol

15. As work progressed, three potentially confounding trends in populations of several turtle species on Lake Conway appeared: (1) the number of individuals observed on permanent shoreline sites was decreasing through time, (2) several species apparently had home ranges much larger than the size of the permanent shoreline sites, and (3) many marked turtles had moved off the permanent sites and into nearby areas perhaps in response to repeated captures. To provide a better understanding of the demography and movements of turtles, the amount of shoreline censused on herp-patrols gradually was expanded in two pools (=extended herp-patrol).

16. In August 1978 the herp-patrol in South Pool was extended from the southern end of the permanent site to the Detwilder outflow canal (Figure 1). In November 1978 a second South Pool extension was initiated from the bridge to the northern end of the site (Figure 1). Thus, beginning in November 1978 herp-patrols in South Pool covered the permanent site and two extensions, or approximately half of the South Pool shoreline. Also, in November 1978, a herp-patrol extension was begun in West Pool, covering the shoreline from the southern end of the West Pool permanent site to the mouth of Gatlin Canal (Figure 1).

17. Extended herp-patrols involved one run at night at slow speeds with the 25-h.p. outboard on each of the bimonthly sampling trips to Lake Conway for the remainder of the study. Extended herp-patrols were conducted on the same nights as permanent site herp-patrols but with three differences in methodology: (1) only one run per night was done on each extended herp-patrol while the two run procedure was continued on permanent sites, (2) calling frogs were not recorded on the extensions, and (3) stinkpots (*Sternotherus odoratus*) captured on the extensions were processed in the boat and immediately released at the capture site; all other species were brought back to the lab for

processing, as was done on all permanent sites.

Selective Herp-patrol

18. We were concerned that the Floy tags used to tag *Sternotherus odoratus* may have become a significant mortality factor and may have contributed to declines in this species on permanent sites. To control for this possibility, "selective herp-patrols" were established in November 1978 in South Pool and September 1979 in West Pool (Figure 1). Selective herp-patrols were similar in all respects to extended herp-patrols except that on selective herp-patrols individuals of *S. odoratus* were not captured or marked, only visually censused and recorded. On selective herp-patrols, all other turtles species were captured and processed in the usual manner (see Godley et al. 1981, for details).

Alligator Census

19. The alligator population of the entire Lake Conway complex was estimated every other month using nocturnal censusing procedures previously described in detail (Godley et al. 1981). These procedures provided estimates of the number, location, and approximate size of all alligators on Lake Conway. In addition, nesting was monitored by searching all stretches of suitable shoreline for alligator nests and determining the relative success of each nest during the summer nesting season.

Other methods

20. In addition to the above sampling methods, several other techniques (gill netting, shoreline census, hyacinth sieving, electro-fishing) were used for selected species as time and man-power permitted. These techniques and the procedures used for measuring and marking all captured amphibians and reptiles are described elsewhere (Godley et al. 1981). Late in the study we successfully used "muddling" to capture large turtles beneath dense hyacinth mats. Specimens were located by hand in a random search beneath mats of waterhyacinth often anchored by emergent cattails. Most success was achieved when water depth was less than 1 m. and mats exceeded 20 $m.^2$.

Data Analysis

21. All data were analyzed using an IBM 3033 computer and Statistical Analysis Systems (SAS) programs (Barr et al. 1979). For most species discussed in this report the information presented was gathered in the first three study

years only. However, for some rare or otherwise poorly known species (such as *Chrysemys picta*, *Kinosternon baurii*, *Pseudemys scripta*, *Trionyx ferox*, and *Nerodia fasciata*), data collected in the fourth study year also are given to provide a more complete account of their natural history on Lake Conway. In addition, radiotelemetry data for certain species (e.g., *Amphiuma means*, *K. baurii*) were limited and are included here; detailed analysis of movement patterns of common radiotelemetried species will be presented elsewhere.

22. Two common measurements of body size are abbreviated in this report: carapace length (CL = straight mid-line distance measured with calipers from anterior-most to posterior-most point on the carapace of turtles), and snout-vent length (SVL = measured from tip of snout to posterior margin of vent for all other species).

PART III: THE LAKE CONWAY SYSTEM

23. Lake Conway is a 743.0 ha. urban lake located in South Orlando, Orange County, Florida (Figure 1). The lake consists of five interconnecting pools which include Lake Gatlin, Little Lake Conway (East and West Pool), and Lake Conway (Middle and South Pool). The lake system is mesotrophic with gradually increasing eutrophic conditions as one proceeds north through the five pools (Conley et al. 1979). The substratum is primarily sand, except in areas of thick vegetation near shore or in dredged canals where organic detritus or silt has accumulated. The bottom contours are rather steep when compared with most central Florida lakes. More than 30% of the total lake bottom is deeper than 6.0 m. (Schardt et al. 1981).

24. During the baseline study period, Illinois pondweed (*Potamogeton illinoensis*) and eelgrass (*Vallisneria americana*) were the dominant shallow-water (<2.0 m.) submergent macrophytes in most pools; stonewort (*Nitella megacarpa*) and hydrilla (*Hydrilla verticillata*) predominanted in water from 2-6 m. deep (Schardt et al. 1981). During the first and second post-stocking years, most marcrophyte species decreased in distribution and abundance. An exception was eelgrass, which is not a preferred food of the white amur (Schardt et al. 1981).

25. Most of the emergent vegetation on Lake Conway had been removed for beach development prior to the initiation of the LSOMT. This trend of habitat modification and destruction was documented for the five years prior to our work (Williams et al. 1982) and continued during the study. However, a narrow fringe of maidencane (*Panicum hemitomon*), lake rush (*Fuirena scirpoides*), pickerel weed (*Pontederia lanceolata*), or cattail (primarily *Typha latifolia*) persisted in some areas.

26. The herpetofaunal community analysis report (McDiarmid et al. 1983) provided descriptions of each permanent shoreline sampling site and a chronology of important changes in the habitat at these sites; this information is used in the species accounts but is not repeated here. In addition, Appendices A and B of the community report summarized the vegetation and substratum characteristics of each permanent trapping station for all sites during the first and second post-stocking periods respectively. These

appendices can be compared directly with baseline conditions (Appendix A of Godley et al. 1981).

PART IV: SPECIES ACCOUNTS

27. During the three-year study on Lake Conway, 11,928 individuals of 12 species of amphibians and 17 species of reptiles were recorded (McDiarmid et al. 1983). As expected, the quality and quantity of information gathered for each species varied with its relative abundance, as did our ability to detect changes in life-history parameters and to attribute these changes to a specific cause. The taxonomically-arranged species accounts which follow were designed to identify spatial and temporal changes in five general aspects of the ecology of each species and focused on several specific questions within each topic.

Distribution and Habitat Preferences

28. What is the relative abundance of the species by pool and by study site? Does the distribution of the species vary with vegetation, substratum, or water depth? How have these distributions and habitat preferences changed since the introduction of white amur, and how are they related to alterations in macrophyte standing crop?

Activity Patterns

29. How does a species' activity vary with the diel cycle? How does it vary annually? What is the home range of the species? Have these patterns of activity changed during the three-year study?

Population Demography

30. What is known of the species' size (age) structure, sex ratio, length-weight relationship, relative or absolute density, and mortality schedule on Lake Conway? Do these life-history parameters vary in time or space, and if so, why?

Food Habits

31. Does the diet of a species vary with size (age), sex, season, or year? If temporal shifts in diet are observed, are they correlated with the aquatic plant control program on Lake Conway?

Reproduction and Growth

32. What is the minimum size at which a species begins to reproduce? What are the seasonal and annual patterns of reproduction and growth in the species? If variation is detected, what might be the causal agent?

33. Each species account follows this basic outline. For some species,

especially those that were rare or difficult to study, one or more aspects of their ecology on Lake Conway remain poorly known and their treatment is necessarily superficial. For other more common and easily collected species, the opposite is true. Data often were very extensive and only those that pertain directly to the objectives of this study were included. Indeed, for several of these species, the Lake Conway study provides the most complete published account of their natural history.

AMPHIBIA: CAUDATA

34. Four species of salamanders belonging to the three families, Amphiumidae (*Amphiuma means*), Plethodontidae (*Eurycea quadridigitata*), and Sirenidae (*Pseudobranchus striatus* and *Siren lacertina*), are known from Lake Conway. The species of *Siren* and *Amphiuma* utilize aerial respiration and are behaviorally and ecologically tied to the water's surface. All four salamanders occur in the vegetated littoral zone. *Siren lacertina* is a large, primitive species that also frequents the open water environments of Lake Conway, where it must occassionally surface to breathe. As a taxonomic unit, salamanders were of minor importance on Lake Conway, making up only 5.2% of the total herpetofaunal observations. However, two of the species (*S. lacertina* and *A. means*) were dominant and conspicuous elements of the littoral zone and accounted for 59.3% of the total funnel trap sample (Table A1).

Amphiuma means (Two-toed amphiuma)

Distribution and Habitat Preferences

35. *Amphiuma means* was the most frequently recorded salamander on Lake Conway, accounting for 61.3% of the total sample of Caudata (Table A2) and 70.1% of the salamanders on permanent sites (Table A3). *A. means* was taken primarily in funnel traps (91.9% of 381 individuals) and comprised 44.8% of the total funnel trap sample (Table A1). In order of decreasing abundance the species was collected most commonly in East Pool (N=235), followed by West (88), South (25), Middle (17) and Gatlin (16) (Table A3).

36. Funnel trap point analyses of permanent sites provided in McDiarmid

et al. (1983) suggest that the distribution of *A. means* by trap station was not random. For example, in SY1 the 21 *A. means* captured in South Pool were taken at only 10 of the 47 trap stations; in West Pool 88.7% of the individuals were taken at stations where only 31.9% of the traps were set (see Fig. 3 and 31 of Godley et al. 1981). To examine habitat selection in *A. means*, only the first two study years were analyzed. Perusal of Table A4 shows that 91.7% of the individuals taken in funnel traps on permanent sites was obtained in this time period; inclusion of the third year substantially flattens the distribution of individuals but does not change the rank-order of habitat preferences. No yearly changes in habitat use were detected.

37. At permanent site trap stations two related aspects of habitat selection were examined: vegetation and substratum. Habitat availability was calculated by summing for all sites the total number of traps set in a particular habitat type. Appendix A of Godley et al. (1981) and Appendices A and B of McDiarmid et al. (1983) provide summaries of dominant vegetation and substratum condition for each trap station used in these analyses. These availability data were then compared with the total number of *A. means* captured at each trap station to evaluate habitat selection.

38. Figure 2 displays the mean relative density (± 95% confidence limits) of *Amphiuma means* by the dominant vegetation summed over all permanent site trap stations on Lake Conway. These habitats are ranked by increasing mean depth of the detrital layer for each plant species. The highest relative density of *A. means* occurred at stations dominated by *Eichhornia crassipes* ($\bar{X}$=14.21/100 trap days), followed by *Typha latifolia* ($\bar{X}$=8.61) and *Pontederia lanceolata* ($\bar{X}$=3.75). Relatively few captures were obtained in two species of *Panicum*, *Nuphar luteum*, or *Fuirena scirpoides*. No *A. means* was collected on beaches even though 15.7% (N=958) of the traps were set in this habitat.

39. The influence of substratum on habitat selection in *A. means* is complex. Figure 2 shows that the mean depth of the detrital layer varied with plant species as did the density of *A. means*; however, the rank-order was not perfect. Both *Nuphar luteum* and *Panicum repens* had moderately deep detrital layers but yielded relatively few captures, suggesting that plant cover and sampling site (see below) confounded the influence of substratum. When trap stations were scored by depth of detritus independent of vegetation (Fig. 3),

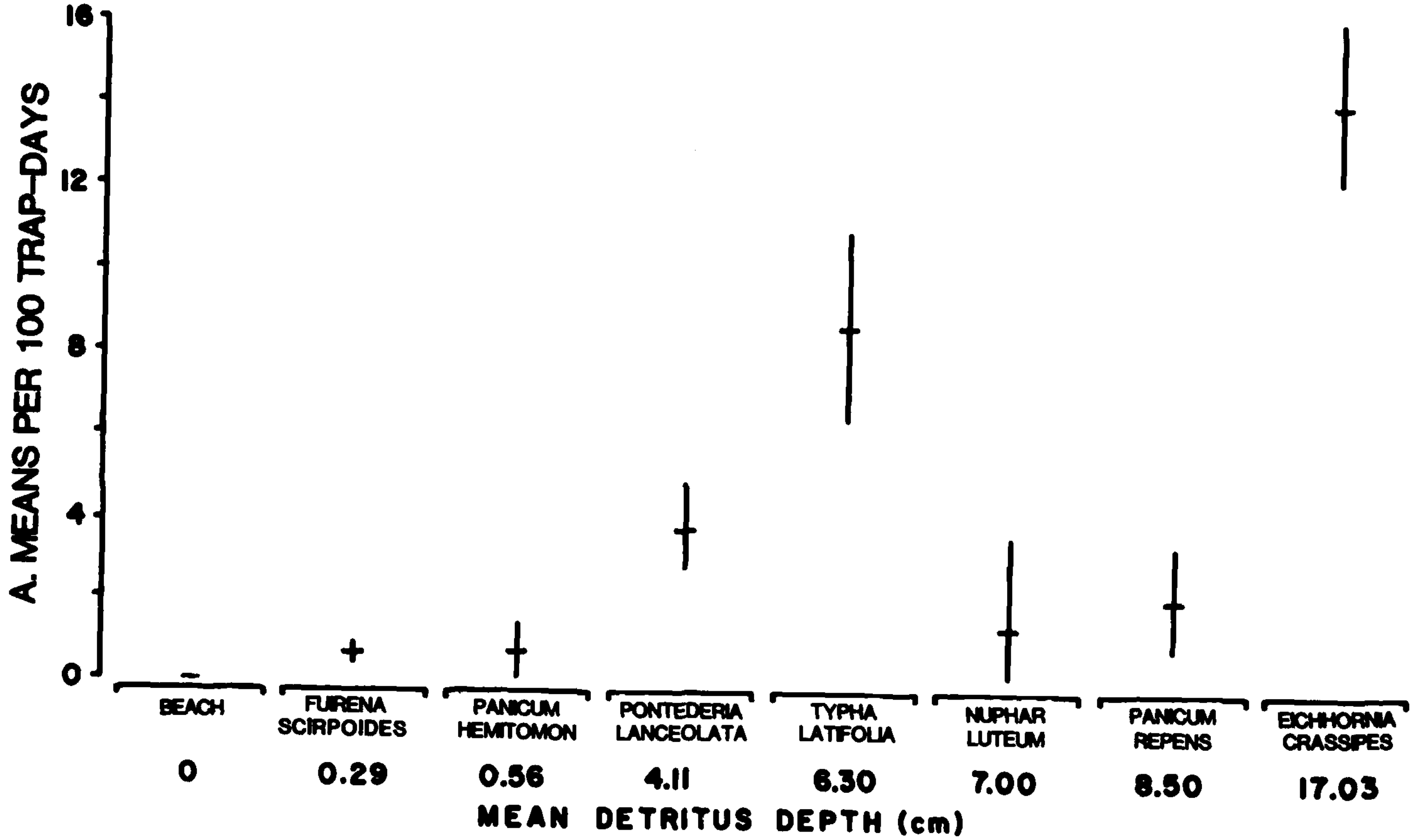

Figure 2. The relationship between the relative density of *Amphiuma means* and the dominant vegetation at littoral zone trap stations during SY1 and SY2. Horizontal lines represent the mean density per 100 trap days; vertical lines represent the 95% confidence limits about the means. See text for details.

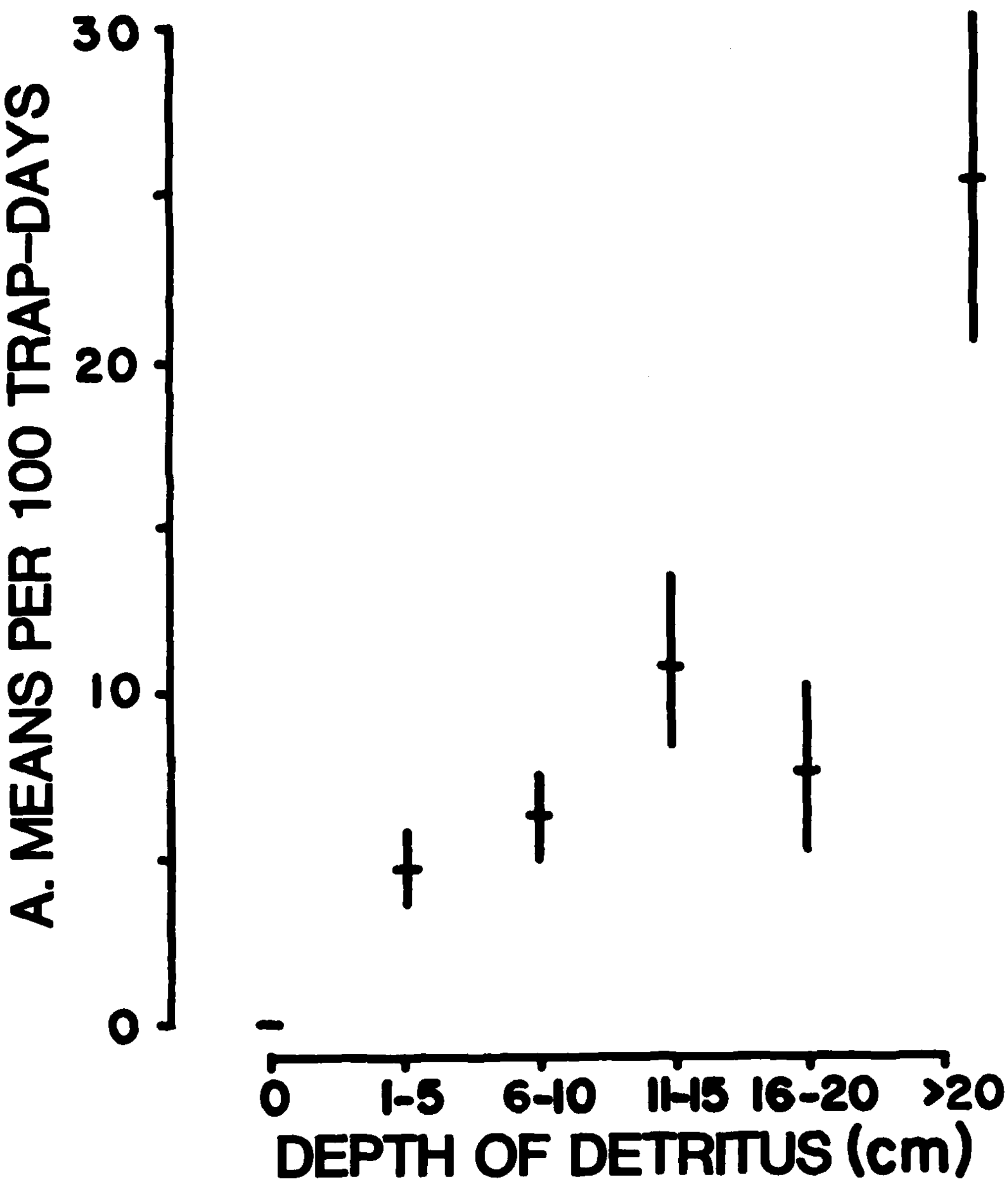

Figure 3. The relationship between the relative density of Amphiuma means and the depth of the detrital layer at littoral zone trap stations during SY1 and SY2. Horizontal lines represent the mean density per 100 trap days; vertical lines represent the 95% confidence limits about the means. See text for details.

the correlation with A. means density is quite striking. An analysis of substratum conditions at trap stations dominated by Eichhornia crassipes produced a similar result; i.e., the density of A. means increased with increasing detrital depth.

40. Although no sexual differences in habitat selection were detected, ontogenetic shifts in habitat use apparently occurred. Chi-square analysis (Table 1) showed that most differences between the size classes of A. means occurred in the deeper substrata. Adults were collected more frequently than expected in detrital depths of 16-20 cm. and juveniles were unusually abundant in very deep (>20 cm.) substrata. With regard to distribution by plant species (Table 2), a preponderance of juveniles occupied Eichhornia crassipes habitats (which also were associated with the deepest substrata, see Fig. 2), and adult A. means were encountered more frequently than expected in Pontederia lanceolata and Typha latifolia.

41. The availability of particular plant associations and substratum conditions probably explains much of the variation in the density of Amphiuma means both within (see point analysis figures in McDiarmid et al. 1983) and between (Table A4) permanent sites. For example, only 12% of the total trap stations had a detrital layer greater than 10 cm., but these stations accounted for 55% of the total A. means captures. The percentage of trap stations with a detrital depth greater than 10 cm. also varied with the permanent site (South Pool = 6.4%, Middle Pool = 15.0%, West Pool = 21.6%, Gatlin Canal = 40.0%, East Pool = 55.0%), and was in close rank-order agreement with mean funnel trap capture rates at these sites (Table A4). The only disagreement was between West Pool and Gatlin Canal, which ranked third and fourth with respect to the mean relative density of A. means but showed an order reversal with regard to detrital depth. This anomaly is explained by the past history and origin of the detrital layer at the sites. Whereas the accumulation of decayed vegetation caused the buildup of mucky detritus at all other sites, in Gatlin Canal thick silt deposits (>10 cm.) were the result of past dredge and fill operations. This "artificial" detrital layer also explains the relatively low capture success at sites dominated by the plants Nuphar luteum and Panicum repens (Fig. 2). All permanent site trap stations where N. luteum (N=4) and P. repens (N=14) were the dominant plant species occurred in Gatlin Canal. In

Table 1

Chi-square analysis of the distribution of adult (>400 mm. SVL) and juvenile (<400 mm. SVL) *Amphiuma means* by vegetation type on the permanent shoreline sites during the first two study years. In the vegetation analysis EC = *Eichhornia crassipes*, PR = *Panicum repens*, PL = *Pontederia lanceolata*, TL = *Typha latifolia*, and O = other plant species including *Fuirena scirpoides*, *Nuphar luteum*, *Panicum hemitomon* and beach habitat.

	Vegetation Type					
	EC	PR	PL	TL	O	Total
Adults						
Observed	82	5	30	30	8	155
Expected	95.7	4.9	23.4	25.6	5.4	
Chi-square	2.0	0.0	1.9	0.8	1.2	
Juveniles						
Observed	94	4	13	17	2	130
Expected	80.3	4.1	19.6	21.4	4.6	
Chi-square	2.3	0.0	2.2	0.9	1.4	

Table 2

Chi-square analysis of the distribution of adult (>400 mm. SVL) and juvenile (<400 mm. SVL) *Amphiuma means* by substrate condition on the permanent shoreline sites during the first two study years.

	Depth of Detrital Layer (cm.)						
	0	1-5	6-10	11-15	16-20	>20	Total
Adults							
Observed	1	36	39	30	28	21	155
Expected	0.5	35.4	37.0	29.4	18.5	34.3	
Chi-square	0.4	0.0	0.1	0.0	4.9	5.1	
Juvenile							
Observed	0	29	29	24	6	42	130
Expected	0.5	29.6	31.0	24.6	15.5	28.7	
Chi-square	0.5	0.0	0.1	0.0	5.8	6.1	

more natural settings, both plant species typically grow in areas with little or no detritus. This "Gatlin effect" also contributed to the comparatively low density estimate ($\bar{X}$=7.80 A. means/100 trap days) for the substrate category 16-20 cm. in Fig. 2; of the 11 trap stations on Lake Conway with this detrital depth, four were in Gatlin Canal.

Activity Patterns

42. Figure 4 shows the relation between mean monthly funnel trap captures for Amphiuma means on Lake Conway and water temperature averaged over the first two years of the study. Water temperature alone accounts for 74.9% of the variance in monthly capture rates, suggesting that activity in this species is strongly tied to ambient temperature regimes. Cagle (1948:484) suggested that activity in Amphiuma tridactylum was related to rainfall but did not provide corresponding information on the effects of water temperature.

43. Amphiuma means is strongly nocturnal. During SY1 when traps were checked at dawn and dusk (see paragraph 11 of Godley et al. 1981), only 11 (4.8%) of 230 A. means captures occurred during daylight hours. No seasonal differences in diel activity cycles were detected (X^2=1.81, P>.75). Interestingly, on Lake Conway a nocturnal activity pattern was maintained in waterhyacinth (Eichhornia crassipes) associations, which are dark beneath the mat even during daylight hours.

44. Analysis of recapture records and the results of radiotelemetry of two adult A. means indicate that this species is sedentary with very small home ranges. Of 25 individuals recaptured up to 532 days later, 60% were taken at the same trap station, 84.0% had moved 10 m. or less, and none was recaptured further than 50 m. from its release point. One male A. means radiotelemetried from 14 May to 12 September 1980 (55 sightings) had a total home range of 12.4 $m.^2$ (minimum polygon method). A male A. means accidentally released 190 m. from its capture point returned within 2 weeks, and remained there for the life of its battery (1.2 months). The restricted home range and apparent homing behavior of A. means probably are related to its social interactions and territorial behavior (see below).

Population Demography

45. In this study, sex was determined either by necropsy or external examinations of the cloaca of living specimens (Baker 1945). Gonadal

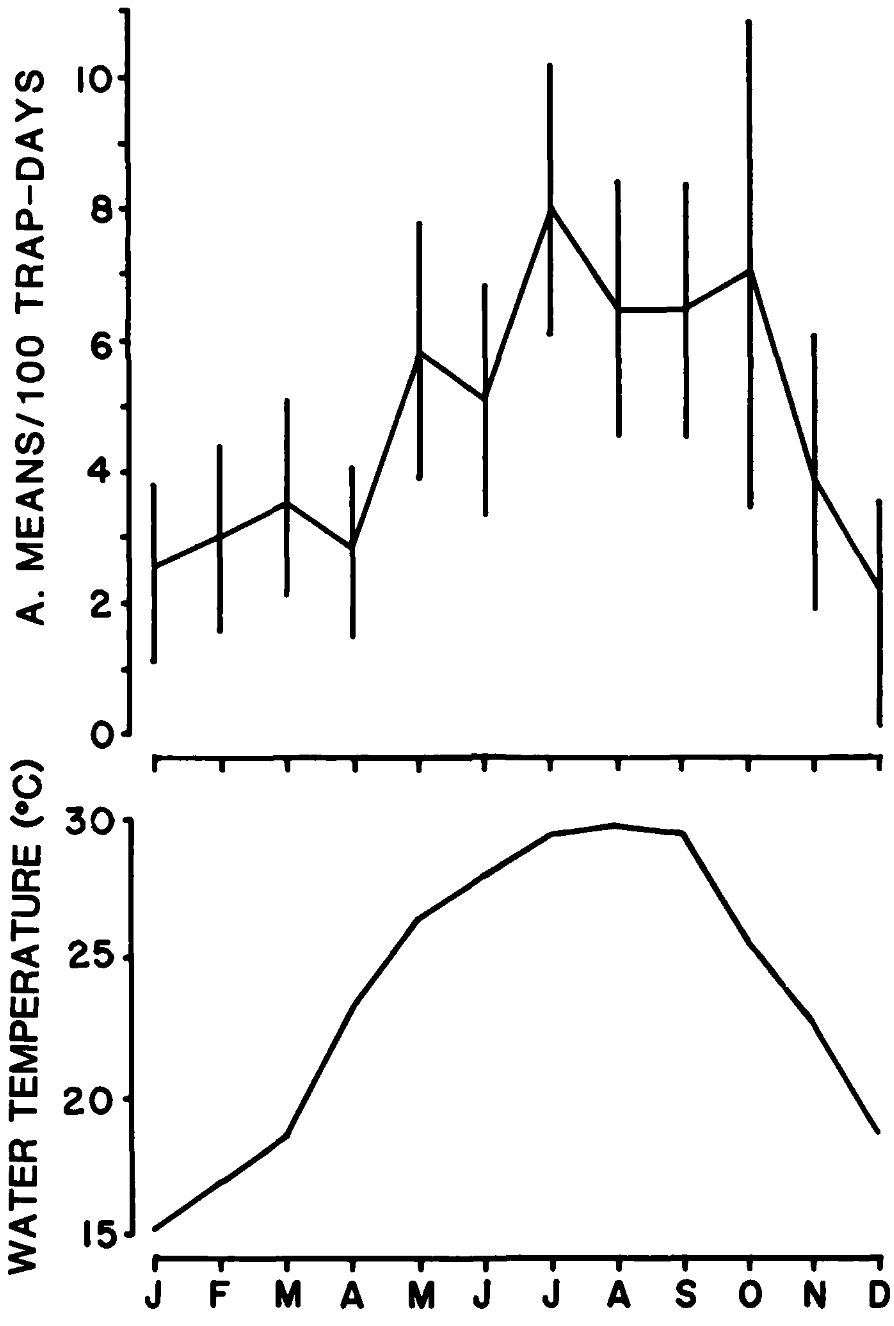

Figure 4. The relationship between mean monthly funnel trap captures of Amphiuma means (vertical lines = 95% confidence limits) and mean monthly water temperature during SY1 and SY2.

examination of 34 A. means sexed initially in the field and later necropsied showed that 91.1% of these individuals were sexed correctly in the field; most errors occurred in sexing subadult males. Field sexing of A. means was initiated in June 1978 and a sex was assigned to 73.6% of the captured sample (N=360).

46. Figure 5 shows the size frequency distribution of all sexed Amphiuma means during the first three study years. The mean SVL for 147 females ($\bar{X}$=398.1 mm., 2SE=16.71) was not significantly different from that for 117 males ($\bar{X}$=404.5 mm., 2SE=19.62). The longest individuals in the population were males: the five longest males ranged in size from 572 to 643 mm. SVL, the five longest females from 567 to 600 mm. SVL. Although males also averaged slightly heavier in body weight ($\bar{X}$=168.7 g.) than females ($\bar{X}$=148.6 g.) the heaviest individual was a female (718.0 g.) followed by a male (641.0 g.).

47. As mentioned previously (paragraph 35), most (91.9%) Amphiuma means taken on permanent sites were collected in funnel traps. This method proved to be the most efficient means of collecting this salamander in all habitats and resulted in the least disturbance to the permanent sites. However, several lines of evidence suggest that funnel traps collected a biased sample of the A. means populations on Lake Conway. Individuals must be both mobile and attracted to the cut-fish bait to be taken in funnel traps. Juveniles probably have smaller home ranges than adults, and feed primarily on invertebrate prey (see paragraph 56), and thus, are less likely to be taken in funnel traps. In addition, the mean SVL (188.7 mm.) of 19 A. means taken with the hyacinth sieve on the permanent sites was significantly smaller (χ^2=44.41, P<.0001) than the mean for 338 funnel-trapped animals (407.8 mm.). Whereas 73.7% of the sieve sample were juveniles less than 250 mm. SVL, only 3.6% of the funnel-trapped individuals were in this size category. Presumably the true size structure of A. means on Lake Conway lies somewhere between the results produced by these two sampling methods. Recognizing this bias and the fact that the hyacinth sieve could be used only in waterhyacinths, which did not occur in equal abundance on all sites (see Appendix A of Godley et al. 1981, and Appendices A and B of McDiarmid et al. 1983), all between-year and between-site size comparisons that follow are based only on funnel-trapped animals. In this regard we assume that the bias introduced by funnel traps was consistent and

LAKE CONWAY HERPETOFAUNA DATA

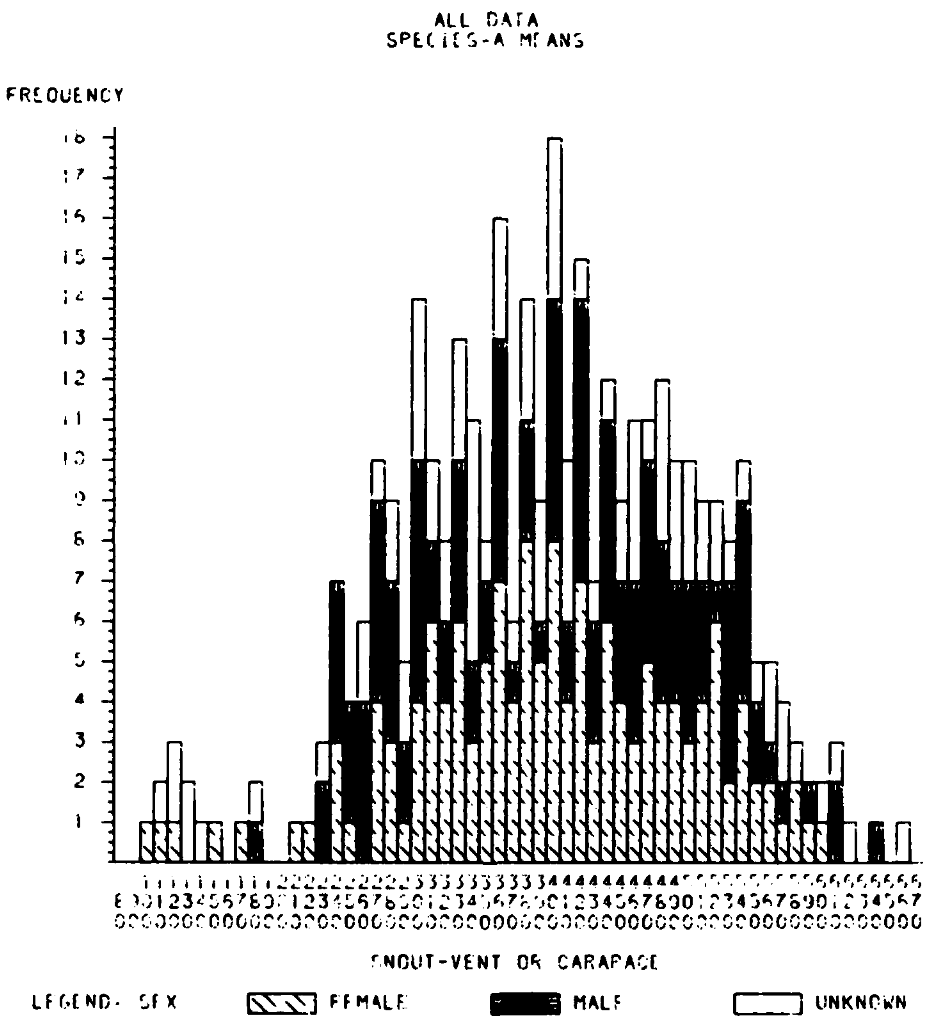

Figure 5. The size frequency distribution of all sexed Amphiuma means collected on Lake Conway.

that any significant between-site or between-year variation represented actual differences in population structure.

48. Table 3 summarizes information on the mean body sizes (SVL) of 338 *A. means* collected on permanent sites during the three-year study. Mean SVL varied by over 100 mm. among the five pools, which represented 24.7% of the average SVL (409.5 mm.) for the entire population. The East Pool population was significantly smaller in body size ($\bar{X}$=382.2 mm.) than all other pools which were not different from one another but ranged in mean SVL from 446.2 mm. (West Pool) to 483.5 mm. (South Pool). Similar between-pool differences in mean SVL were detected in SY1 (χ^2=24.07, P<.001) and SY2 (χ^2=25.86, P<.001), but not in SY3 (χ^2=0.94, P=.816) when sample sizes were reduced considerably (Table A3). Between-year differences were detected in East Pool (χ^2=9.21, P<.05) and for the total lake system (χ^2=13.05, P<.05); this latter result largely was due to yearly differences in East and West Pools.

49. The remarkable variation in average body size of *A. means* between the sites is contrasted strikingly by their mean relative densities at these sites (Table A4), i.e., the rank-order of mean body sizes is inversely related to density. To further determine if density was inversely correlated with body size, the number of different individuals captured at each trap station with captures (a measure of relative density) during the first two study years was plotted against the mean SVL of each relative density subgroup (Fig. 6). To avoid bias, individuals recaptured at the same trap station were excluded from the analysis. Again, the difference in mean body size between high-density (16 individuals at one trap station) and low-density (single individual) trap stations amounted to over 120 mm. SVL. The correlation is highly significant (P=.019) and relative density accounts for 40.9% of the variation in body size.

50. This density-dependent phenomena in *Amphiuma means* could be explained by at least two alternate hypotheses:

a. Survivorship and body size are directly related to density-dependent predation. Under this hypothesis, individuals inhabiting low-density sites would encounter proportionately fewer predators and thus would live longer and grow larger. Per capita food availability and hence growth rates are presumed to be similar in high- and low-density areas.

b. Growth rates and mean body size are directly related to intraspecific competition. Under this

Table 3

Mean snout-vent length in mm. of funnel-trapped *Amphiuma means* taken on the permanent sites at Lake Conway. Yearly and pool comparisons were based on the chi-square approximation of the Kruskal-Wallis test (KW). (* = P .05, ** = P .01, NS = not significant). If significant-between year or between-pool differences were detected (P<.05), pair-wise comparisons were performed. Means with the same letter to the right of a value indicate no significant difference between those pools (P<.025); letters to the left of a value indicate no significant difference between those years (P<.025). See text for details.

	South Pool	Middle Pool	East Pool	West Pool	Gatlin Canal	Species Mean	KW
Study Year 1 (Sample Size)	492.44 (18) A	441.08 (12) B	393.83 (145) B	449.62 (53) A	414.29 (7) B	A 416.99 (235)	24.07**
Study Year 2 (Sample Size)	430.00 (1)	495.67 (3) AB	A 356.62 (45)	441.70 (20) A	532.67 (6) B	AB 399.93 (75)	25.12**
Study Year 3 (Sample Size)	376.00 (1)	-	A 353.47 (19)	366.00 (3)	405.00 (1)	B 358.13 (24)	0.94ns
Mean for Years (Sample Size)	483.50 (20) A	452.00 (15) A	380.85 (209)	444.24 (76) A	464.36 (14) A	407.79 (334)	45.20**
KW	2.04ns	0.75ns	9.21*	3.53ns	6.02ns	13.05**	

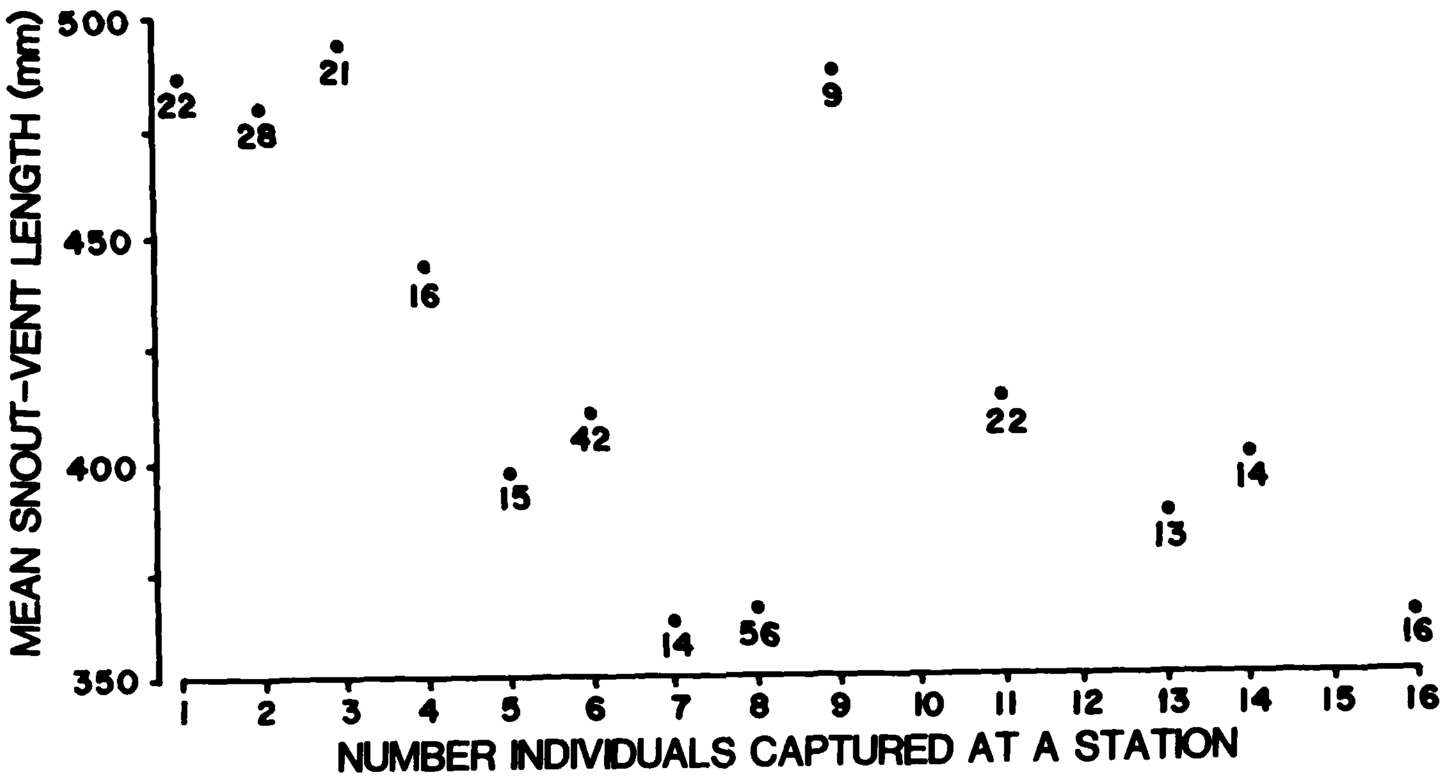

Figure 6. The relationship between the number of different individuals of *Amphiuma means* collected at a trap station and their mean snout-vent length.

> density-dependent mechanism, survivorship is assumed to be similar and food is the limiting resource. Animals from high-density areas would experience increased intraspecific competition and decreased growth rates. Individuals attaining a larger body size are superior competitors capable of aggressively excluding smaller conspecifics from their territories.

51. Partial tests of these hypotheses are available. The only known major predator of A. means is the snake Farancia abacura (Carr 1940, Conant 1975). This snake was collected only on the South Pool and Gatlin Canal permanent sites (Table A3), two pools with relatively low densities of A. means (Table A4). Thus the density-dependent predation hypothesis is not supported by the available data. Because recapture rates of A. means were low, especially from low-density sites (see paragraph 59), it is difficult to evaluate growth rates directly. However, it is possible to examine the relative body mass or "condition factor" of individuals from different pools, years, or relative densities by using analysis of covariance (=CANOVA, Barr et al. 1979) to factor out the effects of differences in snout-vent length. The assumption here is that individuals experiencing intense intraspecific competition should weigh less at a given SVL than those from low-density sites. When such an analysis is performed using log-body mass as the dependent variable and log-SVL, study sites and study years (SY1 vs SY2 and SY3 combined) as independent variables, the model is highly significant ($F=715.11$, $P<.0001$) and accounts for 93.5% of the variance in body mass. As expected, most (98.9%) of this variance is explained by log-SVL, but study sites also account for a significant proportion (1.08%) of the explained variance ($F=9.70$, $P<.0001$). No differences were detected between study years ($F=0.57$, $P=.45$). Among the pools the least squares mean body mass of A. means adjusted to a common SVL was 119.3 g. in West, 124.4 g. in East, 114.1 g. in Middle, 144.7 g. in South, and 157.5 g. in Gatlin: a difference ranging over 38 g. in body mass. As predicted by the intraspecific competition hypothesis, the rank-order of adjusted mean body masses are approximately inversely correlated with density at these sites (Table A4). As a further test of the competition hypothesis, a similar CANOVA was performed using relative density as shown in Fig. 6 and defined in paragraph 49 as an independent variable. In this test relative density was divided into two subgroups: low density (≤ 6 individuals per trap station) and

high density (>6 individuals per trap station). Again the results were significant with regard to relative density ($F=4.24$, $P<.05$); the least squares mean body mass at low density stations was 130.5 g., and 123.9 g. at high density stations.

52. In summary, Amphiuma means showed significant between-site variation in relative density (Table A4), snout-vent length (Table 3 and Fig. 6), and relative body mass on Lake Conway; these differences appear to be largely the result of variation in habitat quality. In addition, significant between-year differences were detected in relative density (Table A6) and mean snout-vent length (Table 3). McDiarmid et al. (1983: paragraphs 34, 61, 104-106) discussed in detail probable causes for the observed yearly changes in the density of A. means on the permanent sites. Although habitat destruction, human disturbance from repeated trapping, trap-shyness, and predation of trapped animals by river otter (Lutra canadensis) all contributed to the declines in A. means density, none of these factors (alone or combined) was a sufficient explanation. Apparently the observed population fluctuations were largely the result of unknown natural causes. In addition, no evidence implicates the white amur plant control program on Lake Conway as a probable cause.

Food Habits

53. The stomach contents of 74 Amphiuma means, representing 21.7% of the total captured sample from Lake Conway, were examined (46 in SY1, 11 in SY2 and 17 in SY3). A majority (86.5%) of the A. means taken for food habits was collected in funnel traps and 4.1% of these contained only trap bait. Because trap bait was not natural prey and was easily identified, it was not included in the analysis.

54. Most (83.8%) Amphiuma means had food other than trap bait in their stomachs (Table 4). Those individuals with food contained predominantly animal prey (74.3% of the stomachs, 94.2% of prey biomass). A total of 155 prey items of 36 genera were identified. Crayfish (Procambarus fallax), aquatic insects, and fish were the dominant prey categories by percent of stomachs (35.1%, 33.8% and 27.0%, respectively) and prey number (17.4%, 31.6%, and 25.8%, respectively). Fish contributed most to prey biomass (55.2%) followed by crayfish (22.5%); insects were of minor importance (4.3%).

55. Vegetative matter also was found in 41.9% of the A. means. Waterhyacinth rootlets and filamentous algae occurred in 70.9% and 9.6% respectively of the 31 stomachs containing vegetation. Plant material contributed little to prey biomass (5.8%) and occurred alone in only two stomachs. This suggests that on Lake Conway A. means ingests plant material inadvertently while consuming animal prey.

56. Comparisons of stomach contents of 14 subadult (<250mm. SVL) and 60 adult (>250mm. SVL) Amphiuma means suggest ontogenetic changes in diet (Table 5). The majority (64.3%) of subadult A. means stomachs with food contained insect prey. Aquatic insects contributed 61.5% to the total number and 22.7% to the biomass of prey taken by subadults. As A. means reached maturity (>250mm. SVL) crayfish and fish assumed greater importance in the diet. Although more adults contained crayfish (40.0%) than fish (30.0%), fish accounted for 56.3% of the total prey biomass compared to 22.0% for crayfish.

57. Oliver (1955) provided the only comparative study of the diet of A. means. He found that the diet of this salamander was by volume 34% insects, 20% amphibians, 17% fish, 13% crayfish, 12% reptiles, 3% snails and 1% spiders. On Lake Conway similar prey taxa were taken but fish and crayfish dominated the prey biomass; insects and amphibians were less important. These dietary differences may be due to differences in habitat, population size structure, or sampling methods. In our study A. means was collected primarily in funnel traps, which also trapped many fish and crayfish but relatively few insects. We suspect many prey were eaten by A. means while they were in the trap thus biasing our sample to some unknown degree.

58. Yearly comparisons showed little difference in percentage of stomachs containing plant matter (Table 6). However, the percentage of empty stomachs dropped from 26% in SY1 to 0% in SY2 and SY3 and was accompanied by a corresponding increase in the percentage of stomachs containing animal matter, especially crayfish and insects (Table 6). These prey taxa also increased in prey number and biomass in SY2 and SY3 combined. The reduction in the percentage of empty stomachs from pre- to post-stocking years is significant (χ^2=13.51, P<.005), and is correlated with declines in the relative densities of A. means on the permanent sites (Table A4). We believe that this may represent a density-dependent response, i.e., as the density of this salamander

Table 4

The diet of 74 *Amphiuma means* from Lake Conway.

Prey taxa	Number (%) of individuals containing prey taxa		Number (%) of prey taxa		Weight (%) of prey taxa in g.	
EMPTY	12	(16.2)				
PLANT TOTAL	31	(41.9)			6.96	(5.8)
Eichhornia crassipes rootlets	21	(29.6)			3.72	(3.1)
Filamentous algae	3	(4.1)			0.80	(1.0)
Other plants	8	(10.8)			2.44	(2.0)
ANIMAL TOTAL	55	(74.3)	155	(100.0)	113.30	(94.2)
Gastropoda	4	(5.4)	7	(4.5)	4.55	(3.8)
Crustacea	27	(36.5)	30	(19.4)	31.42	(26.1)
Procambarus fallax	26	(35.1)	27	(17.4)	27.02	(22.5)
Insecta	25	(33.8)	49	(31.6)	5.16	(4.3)
Osteichthyes	20	(27.0)	40	(25.8)	66.34	(55.2)
Other animals			32	(20.6)	10.03	(8.8)

Table 5

The diet of 14 subadult (<250 mm. SVL) and 60 adult (>250 mm. SVL) *Amphiuma means* on Lake Conway.

Prey taxa	Number (%) of individuals containing prey taxa		Number (%) of prey taxa		Weight (%) of prey taxa in g.	
	Subadults	Adults	Subadults	Adults	Subadults	Adults
EMPTY	1 (7.1)	11 (18.3)				
PLANT TOTAL	3 (21.4)	28 (46.7)			0.16 (6.1)	6.80 (5.8)
ANIMAL TOTAL	12 (85.7)	50 (83.3)	39 (100.0)	116 (100.0)	2.49 (93.9)	110.80 (94.2)
Gastropoda	1 (8.3)	3 (5.0)	3 (7.7)	3 (2.6)	0.02 (0.8)	1.47 (1.2)
Crustacea						
Procambarus fallax	2 (14.3)	24 (40.0)	2 (5.1)	25 (21.5)	1.18 (44.4)	25.80 (22.0)
Insecta	9 (64.3)	16 (26.7)	24 (61.5)	25 (21.5)	0.60 (22.7)	4.56 (3.9)
Osteichthyes	2 (14.3)	18 (30.0)	2 (5.1)	38 (32.9)	0.13 (4.9)	66.21 (56.3)
Other animals	2 (14.3)	8 (13.3)	8 (20.6)	25 (21.5)	0.56 (21.1)	12.76 (10.84)

Table 6

The number and percent of *Amphiuma means* stomachs containing the three major dietary categories in SY1 and SY2 and 3 combined.

Study Year		Empty	Plant	Animal	Total
1	(N)	12	18	26	46
	(%)	26.1	39.1	56.5	
2 & 3	(N)	0	13	26	28
	(%)	0	46.4	100.0	

decreased food availability per individual increased.

Growth and Reproduction

59. An estimate of average growth rates can be obtained from the 27 *Amphiuma means* recaptured on Lake Conway. Capture dates were greater than 90 days apart for 11 of these (range=91-329 days), and nine of the 11 showed growth. For these nine individuals the mean growth rate in SVL per year was 21.41 mm. (range=10.4-29.3 mm./yr.). Most of these were adults. The four smallest individuals (294-355 mm. SVL at initial capture) had faster growth rates ($\bar{X}$=24.12 mm./yr.) than the four largest (465-530 mm.) which averaged 17.33 mm. per year.

60. Unfortunately, small *A. means* (<250 mm. SVL) were rare in the sample and none was recaptured. Accordingly, individual growth rates of juveniles in Lake Conway are unknown, and must be inferred from monthly size frequency distributions for *A. means* (Fig. 7). This, in turn, requires knowledge of the breeding season. Based on what is known of reproduction in the species (Salthe 1973), females are on a biennial cycle. Gravid females move to upland sites and brood the eggs for about five months in underground burrows. Eggs are deposited during the dry season and young, 50-60 mm. total length, hatch during the wet season when high water floods the burrow.

61. On Lake Conway the rainy season typically began in June with highest water levels occurring in September or October. Two females attending egg clutches of 97 and 210 early-stage embryos were excavated 7 m. up on shore 4 m. apart in South Pool on 12 May and 6 June 1979. Only three of 27 preserved females provide additional information pertinent to reproduction. One 478 mm. SVL female contained over 200 enlarged (4.5 mm.) ovarian eggs on 11 May 1980; two post-reproductive females with enlarged oviducts and depleted fat bodies were trapped on 12 and 27 July 1978. These limited data suggest that on Lake Conway most clutches of *A. means* probably are deposited from March through May, and young hatch and enter the water from July through October.

62. The smallest size class present in the Conway sample ranged from 97 mm. SVL in January to 176 mm. by December. Presumably these animals were yearlings growing at about 70-80 mm. per year. At one year of age (about September) these individuals averaged about 150 mm. SVL, which agrees with Cagle's (1948) findings for *Amphiuma tridactylum*. At the end of their second

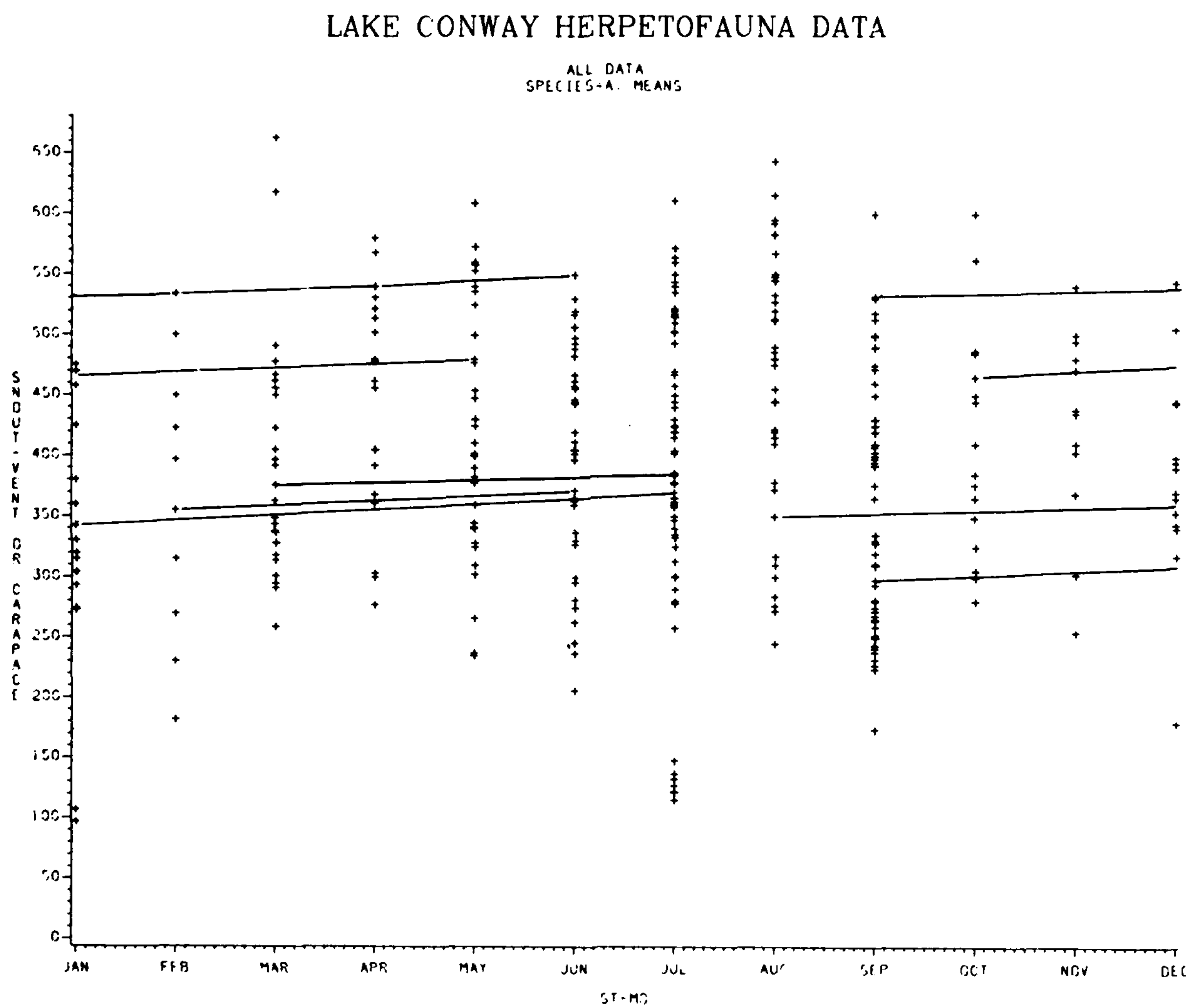

Figure 7. Monthly size distribution of Amphiuma means collected on Lake Conway. Lines connecting points represent growth of recaptured individuals.

year *A. means* on Lake Conway ranged from about 220 to 330 mm. SVL, thus growing on the average about 120 mm. By January these two year olds were 270 to 360 mm. SVL, and may have reached 350 to 420 mm. by September, the beginning of their third year. Thereafter, no distinct size classes were discernible. The suggested growth rates for two (120 mm./yr.) and three (70 mm./yr.) year olds is somewhat higher than that recorded for smaller (294-355 mm. SVL) recaptured *A. means* on the lake system ($\bar{X}$=24.12 mm./yr.). However, none of these marked individuals was recaptured over the warm summer months (Fig. 7) when growth rates probably were highest. In addition, the trauma of capture and branding with liquid nitrogen (Godley et al. 1981, paragraph 25) may have substantially reduced growth in these individuals.

63. The size and age at sexual maturity of *Amphiuma means* on Lake Conway were difficult to establish with the limited number of preserved specimens available (27 females, 36 males). The smallest male (365 mm. SVL) with enlarged testes (0.63 g.) and epididymides was collected in September, but two other small males (365, 376 mm. SVL) taken in October had small testes weighing less than 0.3 g. However, similar asynchrony existed among larger animals. Very few reproductive females were collected (see paragraph 61) and the smallest of these was 475 mm. SVL. A review of the literature (Salthe 1973) suggests that females mature at about 400 mm. SVL. Assuming that this is true on Lake Conway, then males probably first reproduce a year earlier (age three) than females which may delay reproduction until year four.

Eurycea quadridigitata (Dwarf salamander)

64. Only two dwarf salamanders were collected on Lake Conway (Table A2). Both specimens were found in the nest of a round-tailed water rat (*Neofiber alleni*) located in waterhyacinths (*Eichhornia crassipes*) on the East Pool permanent shoreline site on 21 July 1977. A long-time resident of Lake Conway stated that dwarf salamanders once occurred along the shore of South Pool but had not been seen for many years. Presumably the species was more widespread and common on Lake Conway before shoreline development.

65. Mittleman (1967), Powers and Cate (1980), and Semlitsch (1980) reviewed various aspects of the biology of dwarf salamanders. In central and

southern Florida adult E. quadridigitata rarely wander overland, but occur along the margins of lakes and streams, in seepage areas, and in floating, aquatic vegetation where they feed on small invertebrates. Females deposit 6 to 44 eggs attached to vegetation in the water in late winter. The larvae metamorphose by late summer and reach maturity by the following winter.

Pseudobranchus striatus (Dwarf siren)

66. The dwarf siren was the least frequently collected sirenid salamander on Lake Conway. During the study two adult specimens (male and female) were taken in waterhyacinths on the East Pool islands; one in a funnel trap, the other with a hyacinth sieve (Tables A1, A2). The preferred habitat of P. striatus is shallow water clogged with aquatic vegetation (Martof 1972). The species probably was much more abundant and widespread on Lake Conway before the extensive development of its shoreline. Martof (1972) reviewed the biology of this poorly known aquatic salamander. P. striatus feeds on a variety of small aquatic invertebrates. The reproductive season is long with some individuals in reproductive condition all months of the year. Females attach eggs singly to aquatic plants.

Siren lacertina (Greater siren)

Distribution and Habitat Preferences

67. Greater siren was the second most commonly recorded salamander on Lake Conway (N=238) and accounted for 2.0% of the total observations on the lake system (Table A2). Most (61.8%) of these observations were from permanent sites (Table A3) with 10 specimens recorded from South, 13 from Gatlin, 20 from Middle, 30 from West, and 74 from East Pool. The species was taken by a variety of methods but funnel traps (47.06%), herp-patrol (34.03%), and hyacinth sieving (7.14%) accounted for the majority of observations (Table A1).

68. Unlike Amphiuma means, the other common salamander on Lake Conway (Table A2), adult S. lacertina possess lungs and gills, and have a well-formed dorsal and ventral fin used for swimming through the water column. These morphological traits along with a complex suite of physiological and

respiratory adaptations (Ultch 1976) enable this species to occupy both open water and littoral zone environments. Because these two environments on Lake Conway differ considerably in water depth, substratum, and corresponding vegetation, habitat selection in *S. lacertina* is considered separately for each environment.

69. Information on dominant aquatic vegetation is available for sightings of 87 *S. lacertina* in open water (Table 7). Most of these records were obtained when sirens were observed gulping air at the surface. Perhaps the most important observation is the virtual absence of *S. lacertina* from areas with bare bottom. Even though the weighted mean coverage of this habitat increased 26.8% (from 328 ha. to 416 ha.) on the lake system from 1977 to 1980 (Schardt et al. 1981, Fig. J6), no corresponding increase in siren sightings on bare bottom was recorded (Table 7). Of the six individuals seen over bare bottom, all were observed at night near dense vegetation. Vegetation of some sort apparently is required for the maintenance of this species in open water habitats on Lake Conway; the same is true in littoral zone habitats (see paragraph 72).

70. Table 7 shows that the distribution of *S. lacertina* varied significantly with vegetation type over the three-year study (χ^2=31.16, P<.0001). The most notable change was the reduction in the proportion of individuals sighted over *Potamogeton illinoensis*, and the corresponding increase in sightings over *Nitella megacarpa*, and especially *Vallisneria americana*. These shifts in habitat use correspond strikingly with changes in vegetation recorded by Schardt et al. (1981). These authors (Fig. J9) demonstrated a 73.8% reduction (from 183.0 ha. to 48.0 ha.) in the weighted mean percent coverage of *P. illinoensis* on Lake Conway from 1977 to 1980. As this plant species was consumed by white amur, *S. lacertina* shifted its activity to *N. megacarpa* or *V. americana* but the shift varied with the pool. For example, in South Pool by SY3 seven of eight *S. lacertina* sightings were over *N. megacarpa.* Schardt et al. (1981: Figs. J8-J10) showed an 85.7% decrease in *P. illinoensis* coverage form 1977 to 1980 in South Pool but a 26.7% increase in *N. megacarpa; V. americana* was rare in this pool in all years. In East Pool, *P. illinoensis* initially covered 37.0% of the bottom in SY1 but showed an 81.1% reduction by SY3 (Schardt et al. 1981: Figs. J9, J10); *V.*

Table 7

Chi-square analysis of the yearly distribution of *Siren lacertina* in open water habitats on Lake Conway.

	Nitella megacarpa	*Potamogeton illinoensis*	*Vallisneria americana*	Other vegetation	Bare bottom	Total
Study Year 1						
Observed	3	12	0	6	2	23
Expected	4.5	7.1	7.1	2.6	1.6	
Chi-square	0.5	3.3	7.1	4.3	0.1	
Study Year 2						
Observed	4	9	4	1	0	18
Expected	3.5	5.6	5.6	2.1	1.2	
Chi-square	0.4	2.1	0.5	0.6	1.2	
Study Year 3						
Observed	10	6	23	3	4	46
Expected	9.0	14.3	14.3	5.3	3.2	
Chi-square	0.1	4.8	5.3	1.0	0.2	

americana, a plant not preferred by white amur, actually increased 166.7% during this time period. Shifts in the relative and absolute abundances of these two plant species was even more pronounced around the East Pool islands (McDiarmid et al. 1983: paragraph 35). Importantly, of the 23 S. lacertina recorded over V. americana during SY3, 19 of these were from East Pool and 17 of these were from near the islands.

71. To summarize, significant shifts in habitat usage patterns of Siren lacertina occurring in open water environments on Lake Conway were recorded during the study. These shifts were correlated with changes in the distribution and abundance of macrophytes on the lake. Because it appears that S. lacertina is dependent in some way on this plant coverage, and because no reason exists to suspect that populations of S. lacertina were at less than carrying capacity during baseline conditions, we infer that the reduction in macrophyte populations as a result of the white amur has caused a substantial decrease in the number of S. lacertina inhabiting open water environments on Lake Conway.

72. To evaluate habitat selection of Siren lacertina in the littoral zone, the number of individuals captured in each habitat type was compared with the total number of traps set in each habitat (see paragraph 37 for a full description of the methodology). Figure 8 shows that the relative abundance of S. lacertina varied considerably with the dominant plant species at the trap stations. Bare beach habitats clearly were avoided by siren with no captures recorded in 1,797 trap days. Only one specimen was taken in 1,206 trap days in Fuirena scirpoides, a sedge that forms a thin cover on sandy soils. Three other plant species (Panicum hemitomon, P. repens, and Pontederia lanceolata) supported moderate S. lacertina densities ($\bar{X}$=0.56 to 0.74 individuals per 100 trap days). The highest densities were found in Typha latifolia (0.98/100 trap days) and especially in Eichhornia crassipes ($\bar{X}$=1.72/100 trap days).

73. Figure 8 ranks the plant species by the mean depth of the detrital layer associated with each site and suggests that S. lacertina density varies with both plant species and substratum. When trap stations were scored by depth of detritus independent of vegetation, a strong correlation with mean density was observed (Fig. 9). Because substratum condition is correlated with plant species, the relationship of either variable with S. lacertina density is

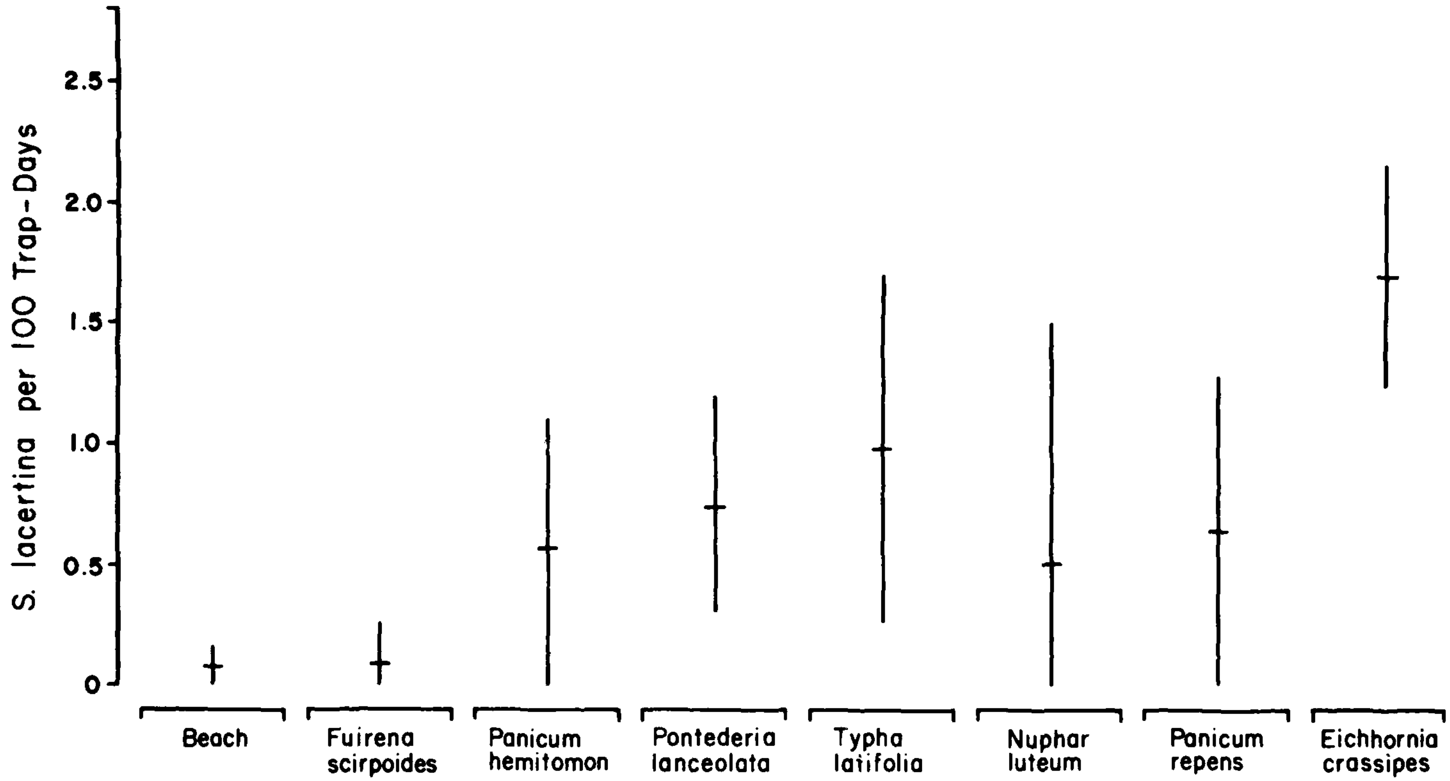

Figure 8. The relationship between the relative density of *Siren lacertina* and the dominant vegetation at littoral zone trap stations during SY1 and SY2. Horizontal lines represent the mean density per 100 trap days; vertical lines represent the 95% confidence limits about the means. See text for details.

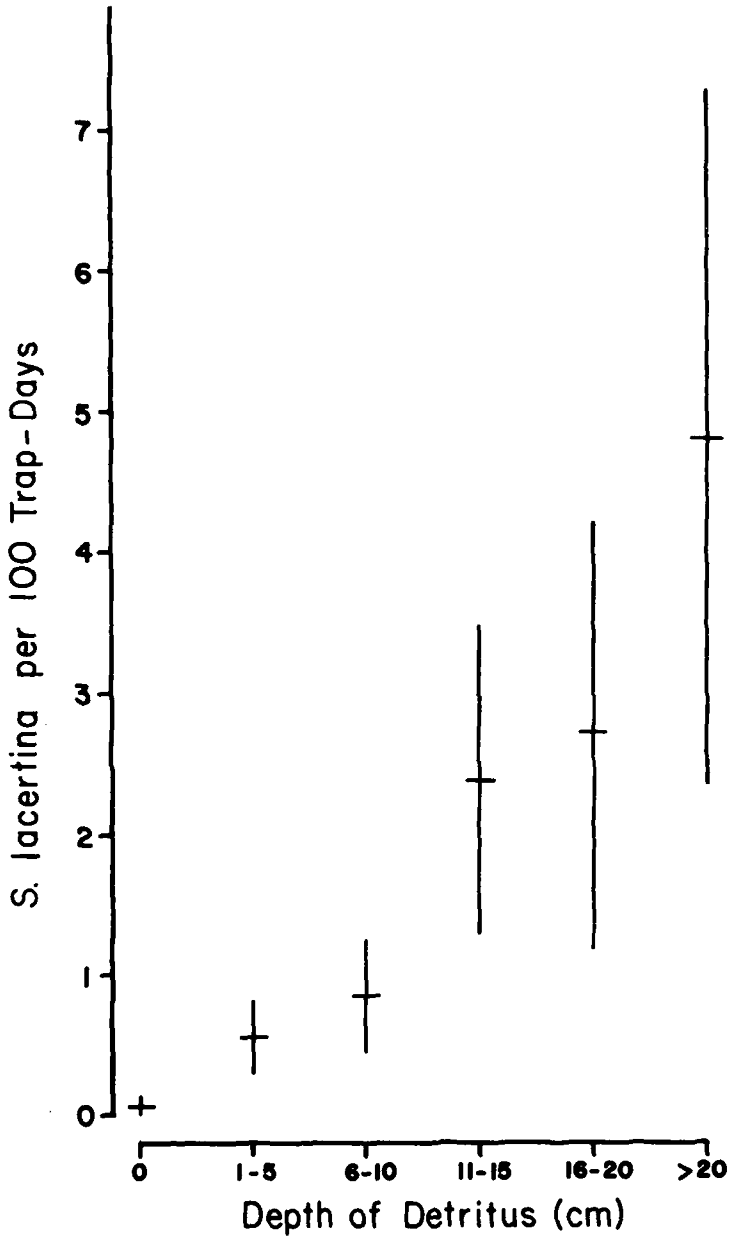

Figure 9. The relationship between the relative density of Siren lacertina and the depth of the detrital layer at littoral zone trap stations during SY1 and SY2. Horizontal lines represent the mean density per 100 trap days; vertical lines represent the 95% confidence limits about the means. See text for details.

complex. In addition, both plant species and substratum may be correlated with other factors (e.g., prey density, predator escape) of more proximate importance to the salamander. For the objectives of this study it is important only that vegetation and substratum conditions can adequately predict the density of S. lacertina: no change in either parameter in the littoral zone as a result of the white amur was detected.

Activity Patterns

74. In the open water environments of Lake Conway Siren lacertina were observed surfacing to breathe during both day and night. All of the individuals (N=6) seen actively foraging on the bottom of the lake were recorded at night. In SY1 funnel traps were checked at dawn and dusk to detect diel activity patterns. Of the 54 S. lacertina obtained during these trap checks, 90.7% were nocturnal captures. The distribution of nocturnal captures did not vary significantly (χ^2=4.56, P=.21) by season (winter=28.6%, N=7 total captures; spring=5.3%, N=19; summer=100.0%, N=10; fall=11.1%, N=18).

75. Figure 10 shows the monthly distribution of Siren lacertina activity in the littoral zone (as measured by funnel trap captures) and in open water (by herp-patrols, radiotelemetry electrofishing, or gill nets) and its relationship with water temperatures and dissolved oxygen concentration. Although no statistics were run, it is apparent that open water sightings of siren peak in July and that the number of open water sightings is positively correlated with temperature and negatively correlated with oxygen concentration. Auto-correlation between water temperature and $[O_2]$ makes it difficult to infer which parameter is biologically more important without performing partial correlation analyses.

76. S. lacertina activity as measured by monthly funnel trap captures in the littoral zone shows a pattern different from open water sightings (Fig. 10). The correlation between littoral zone activity and either environmental parameter is poor, suggesting that S. lacertina is responding to different environmental cues in the littoral zone. In addition, there appear to be two distinct peaks (spring and fall) of activity in the littoral zone with notable depression during the hot summer months when open water sightings reach their maximum. We suggest that some portion of the S. lacertina population on Lake Conway may shuttle seasonally between these two distinct habitats. The

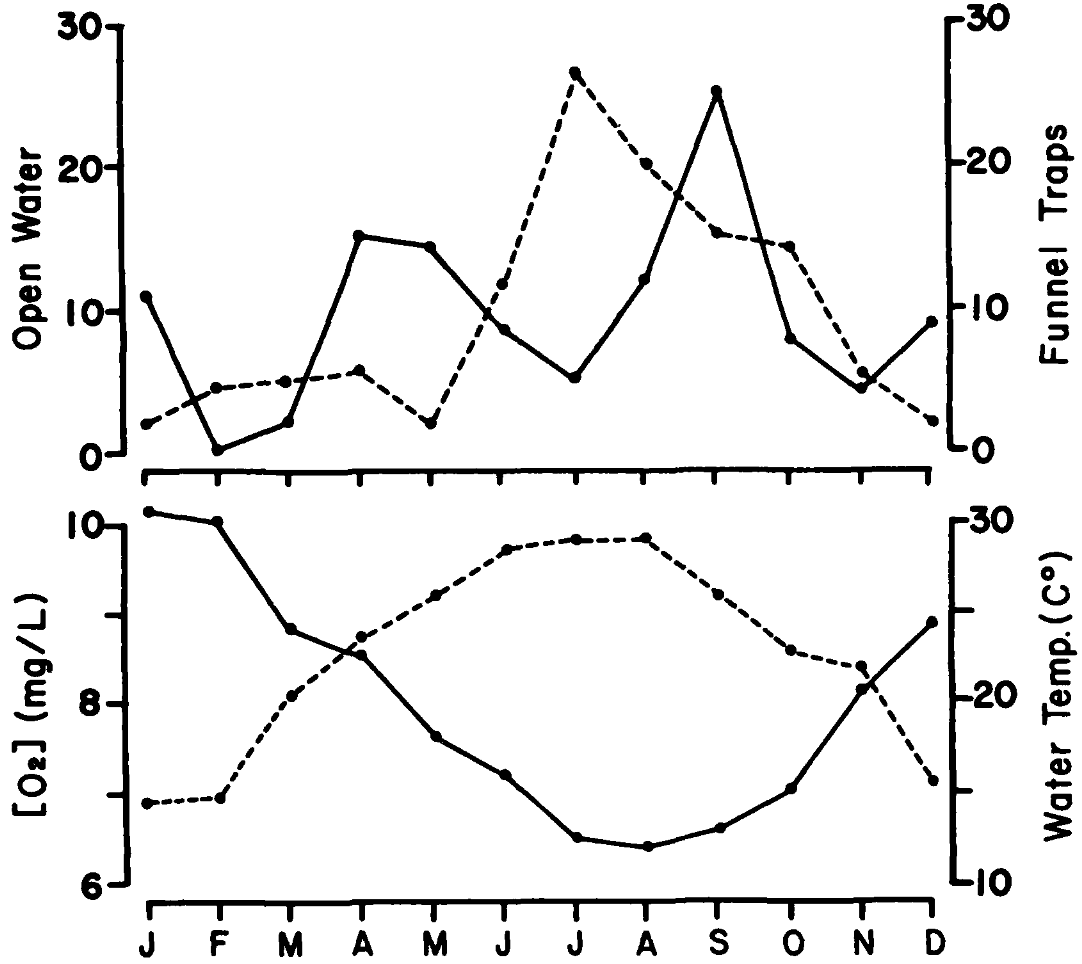

Figure 10. Monthly activity patterns of Siren lacertina in the littoral zone (solid line; dots = means) and in open water (dashed line; dots = total sightings), and their relationship with water temperature (dashed line) and dissolved oxygen concentration (solid line). See text for details.

near-shore peak in spring probably is related to reproduction (see paragraph 91); the cause of the fall peak is unknown.

Population Demography

77. The habitat analysis presented earlier showed that Siren lacertina occupies both open water and littoral zone environments in Lake Conway. To determine if the size structure of siren populations in the lake system varied by habitat, the snout-vent lengths of individuals collected in the littoral zone (by funnel traps or by hyacinth sieving) was compared with those collected or observed in the open water (by herp-patrols, gills nets, telemetry, or electrofishing). Preliminary analyses showed no significant differences in the mean SVL of siren taken by these latter methods; thus, these specimens were lumped into the single category "open water."

78. The size frequency distribution of S. lacertina varied by habitat and by sampling method on Lake Conway (Fig. 11). The mean SVL of 17 S. lacertina taken by hyacinth sieving (149.82 mm.) was significantly smaller than the mean for 113 funnel trapped individuals (281.24 mm.) which also was smaller than the 66 individuals (365.98 mm.) observed in open water (X^2=53.33, P<.0001). Although biases certainly exist with each method [e.g., larger individuals have a higher probability of escaping from the sieve, smaller individuals are less likely to enter a funnel trap (see also paragraph 47) or be seen surfacing in open water], we believe that the samples are representative of the habitats and that the differences are real. Less than 8% (N=5) of the siren observed in open water were smaller than 250 mm. SVL but 45.5% (N=59) of the littoral zone sample were in this size class. At this size S. lacertina averages about 150 g. in wet mass and probably is not large enough to escape predation by several of the carnivorous fish in Lake Conway. Adult S. lacertina migrates to shallow water in the spring to breed (Ultsch 1973). This behavior may be an adaptation to avoid fish predation on juveniles in open water and may explain the spring peak in funnel trap captures near shore (Fig. 10).

79. The mean SVL of 50 female S. lacertina (456.5 mm.) was not significantly different (X^2=0.23, P=.63) from 46 males (445.0 mm.). However, the five longest males (495 to 525 mm. SVL) were all larger than the five longest females (465 to 480 mm. SVL). Because no sexual differences in mean SVL were detected, the sexes were lumped in all size analyses that follow.

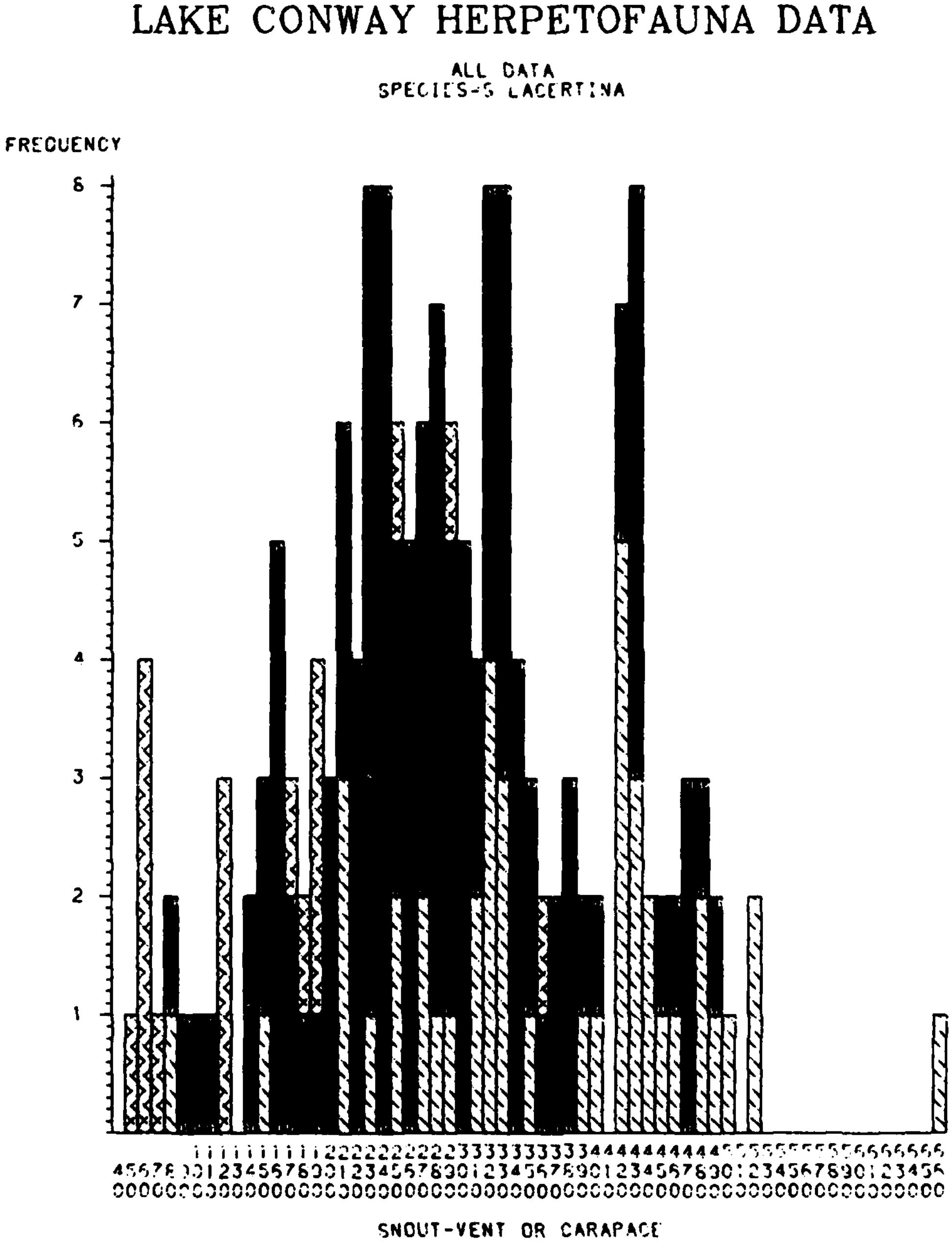

Figure 11. The size frequency distribution of Siren lacertina collected by hyacinth sieving (▨), funnel traps (■), or observed in open water (▧).

80. When the entire sample of captured S. lacertina from Lake Conway was considered, significant differences in mean SVL between the pools were found (χ^2=25.72, P<.0001). The mean SVL of S. lacertina from Gatlin (359.00 mm., N=8), South (352.59 mm., N=10), and Middle Pools (349.17 mm., N=24) were not different from one another but were larger than the mean SVL of individuals from East (277.32 mm., N=101) which were larger than West Pool siren (213.05, N=22). Because mean SVL varied with sampling method (paragraph 78) and because some methods were not used in all pools, these results possibly are biased. To reduce bias a similar size analysis was performed using only funnel trapped S. lacertina, the method which provided the largest sample for the species (Table A2). Similar results were obtained (χ^2=15.78, P=.003) with siren from West and East Pools averaging smaller in SVL than those from other pools. The causes of these observed size differences are unknown.

81. A comparison of mean SVL of Siren lacertina with all pools and methods lumped showed no significant differences among the three study years (χ^2=4.64, P=.20). However, when only funnel trapped S. lacertina were considered, significant between-year differences on permanent sites were detected (χ^2=16.22, P=.001). The mean SVL of animals trapped in SY1 (293.23 mm., N=65) was not different from that of animals taken in SY3 (368.75 mm., N=8), but S. lacertina trapped in SY2 averaged significantly smaller (245.77 mm., N=35) than the other two study years. These yearly fluctuations in average SVL were largely the result of East Pool, which had the highest densities of all pools (Table A6) and showed similar, significant differences (χ^2=10.21, P=.01). The reasons for these yearly fluctuations in body size are not apparent.

82. To determine if body mass relative to SVL of funnel trapped S. lacertina varied by permanent site or study year, an analysis of covariance (=CANOVA, Barr et al. 1979) was performed using log-body mass as the dependent variable, and log-SVL, study sites, and study years (SY1 vs SY2 and SY3 combined) as independent variables. This analysis of the "condition factor" of the animals statistically controlled for the between-pool and between-year differences in SVL described above. The model was highly signficant (F=614.05, P<.001) and accounted for 97.9% of the variance in body mass. Although SVL accounted for most (99.6%) of the explained variance in body mass, study sites

were also significant (F=3.09, P=.02) but explained only 0.38% of the variance. Study years showed no significant effect (F=0.45, P=.50). In general, the least squares mean weight adjusted to a common SVL showed that *S. lacertina* was relatively heavier in Middle and South Pool, and lighter in East, West and Gatlin. Presumably these differences in condition factor reflected variation in habitat quality at these sites.

83. Significant between-site differences in the mean relative density of *Siren lacertina* were detected by both herp-patrol (Table A5) and funnel trap (Table A4) sampling methods. In general, East Pool had the highest densities of *S. lacertina* recorded by either method, but the rank-order of other pools varied with sampling method and study year. Summaries for all study years combined suggest that in the littoral zone on permanent sites (Table A4), siren densities were highest in East Pool ($\overline{X}$=2.09 captures/100 trap days) followed by Middle (1.18), West (0.75), Gatlin (0.53), and South Pool (0.9). On herp-patrols (Table A5) where siren were typically seen in open water habitats, the mean number observed per hour decreased from East (0.72) to Gatlin (0.07), South (0.04), West (0.03), and Middle Pool (0.00).

84. Significant yearly changes in the mean relative density of funnel trapped *S. lacertina* on the permanent sites (Table A4) were recorded for Middle (SY1>SY2=SY3), X^2=14.92, P<.005), East (SY1>SY2>SY3, X^2=69.36, P<.001) and West Pools (SY1=SY2>SY3, X^2=12.18 P<.005), but not South Pool or Gatlin Canal. No statistically significant yearly differences in siren observed on herp-patrols (Table A5) were detected but the steady increase in East Pool from SY1 ($\overline{X}$=0.14 individuals/hr.) to SY2 ($\overline{X}$=0.25) to SY3 ($\overline{X}$=1.73) probably represented real changes in the open water density of siren on that site.

85. The causes of these site and yearly differences in the relative density of *Siren lacertina* were complex and involved a number of factors operating simultaneously. The habitat analysis presented earlier (paragraphs 72-73) clearly showed a hierarchy between the dominant plant species at littoral zone trap stations and the relative density of *S. lacertina*. The dependence of this salamander on specific combinations of plants and substrata probably explains most of the between-site variation in density, i.e., the relative and absolute abundance of high-quality littoral zone habitat varied between the sites. Within-site yearly differences in siren density require

additional explanation. As discussed elsewhere (McDiarmid et al. 1983), habitat destruction, human disturbance from repeated trapping, and otter (Lutra canadensis) predation contributed to the decline of S. lacertina on the permanent sites but the relative importance of each factor is unknown. No reason exists to suspect that the white amur aquatic plant control program caused a reduction in siren densities in the littoral zone.

86. Although no statistically significant yearly differences in the relative density of Siren lacertina observed on herp-patrols were recorded, this probably was an artifact of the Kruskal-Wallis sum-rank test used for the comparisons (see Godley et al. 1981: paragraphs 55-57), especially for East Pool where densities increased considerably during the study (Table A5). One could argue that yearly increases in open water sightings on this site were caused by emigration of siren from the littoral zone trap stations, where densities decreased during the study (Table A4). However, declining littoral zone trap success on the other permanent sites was not accompanied by yearly herp-patrol increases (Tables A5 and A6), suggesting that the increases in siren sightings on East Pool herp-patrols were not caused by changes in density in the littoral zone, but were related to peculiarities of the site. As noted elsewhere (paragraph 70), white amur caused dramatic reductions in the biomass and percent coverage of Potamogeton illinoensis around the islands but Vallisneria americana in some areas increased. This reversal in plant species abundance was especially noticeable along the herp-patrol transect from markers 2100 through 2200, where 71.4% of the S. lacertina sightings were recorded in SY3 (McDiarmid et al. 1983: Fig. 32). Our qualitative observations and those provided by Schardt et al. (1981: Fig. J8-J10) suggest that the patch of V. americana from markers 2100 to 2200 was the only dense, open water plant cover in the immediate area by SY3. All other areas along the north shore of the islands were either bare or supported sparse populations of P. illinoensis, V. americana, or Nitella megacarpa. This submerged "island" of high-quality habitat probably attracted any siren remaining in the area (see also paragraph 70).

Food Habits

87. A total of 68 Siren lacertina, representing 44.2% of the captured sample for the species on Lake Conway, was available for food habit analysis

(33 in SY1, 17 in SY2, and 18 in SY3). A majority (63.2%) of these individuals was captured in funnel traps; consequently trap bait occurred in 25.0% of the stomachs. In this study trap bait was excluded from all analyses; those animals containing only trap bait were categorized as empty.

88. Most (89.7%) of the Siren lacertina contained food in their stomachs, but seven (10.3%) were empty (Table 8). A majority of the individuals with food contained both plant (73.5%) and animal (77.0%) matter, but plant material dominated the prey biomass (170.4g., 85.5% of total prey weight). A total of 288 animal prey items, consisting of at least 35 genera, were identified. Among the major animal taxa, aquatic insects occurred in the greatest proportion of individuals (35.3%), but snails, especially Planorbella spp., dominated both the numbers of individual prey and prey biomass. Most snails were small and all were swallowed whole. The large quantity of plant material in the stomachs of S. lacertina was comprised chiefly (52.0% of total plant biomass) of filamentous algae (Lyngbya spp.) but Eichhornia crassipes rootlets and Vallisneria americana leaves also were important.

89. The diet of S. lacertina in Lake Conway is consistent with the literature. Burch and Wood (1955) and Hamilton (1950) reported large numbers of snails in the alimentary tracts of S. lacertina. Large quantities of ingested plant material have been reported (Dunn 1924, Scroggin and Davis 1956, Ultsch 1973, Hanlin 1975) with filamentous algae often comprising a major component (Burch and Wood 1955). Scroggin and Davis (1956) argued that Siren ingested plant material accidentally while capturing animal prey. However, the ability of sirens to digest and absorb nutrients from plant matter is unknown (Ultsch 1973) and the role of plant material in their diet is not clear. In this respect it is interesting that 14 of the 61 S. lacertina from Lake Conway that contained food had only plant material.

90. Analysis of yearly trends in the diet of S. lacertina from Lake Conway showed no substantial changes (Table 9). This may be the result of small sample sizes or because diet did not shift with study year.

Growth and Reproduction

91. Of the 67 Siren lacertina marked and released, none was recaptured, Thus, nothing is known about the growth rates of individuals on Lake Conway. Ultsch (1973) reviewed what is known of growth and reproduction in S. lacertina

Table 8

The diet of 68 *Siren lacertina* from Lake Conway.

Prey taxa	Number (%) of individuals containing prey taxa		Number (%) of prey taxa		Weight (%) of prey taxa in g.	
EMPTY	7	(10.3)				
PLANT TOTAL	50	(73.5)			170.39	(85.5)
Filamentous algae	27	(44.3)			88.63	(44.4)
Eichhornia crassipes rootlets	6	(8.8)			2.85	(1.4)
Other plants	18	(26.5)			78.91	(39.6)
ANIMAL TOTAL	47	(77.0)	288	(100.0)	29.01	(14.5)
Gastropoda	18	(26.5)	119	(41.3)	7.45	(3.7)
Planorbella sp.	12	(17.6)	99	(34.4)	6.72	(3.4)
Crustacea	14	(20.6)	19	(5.6)	7.13	(3.6)
Procambarus fallax	10	(14.7)	10	(3.5)	6.36	(3.2)
Insecta	24	(35.3)	35	(12.2)	0.95	(0.5)
Osteichthyes	8	(11.8)	12	(4.2)	2.59	(1.3)
Other animals	5	(7.4)	103	(35.8)	4.94	(2.5)

Table 9

The number and percent of *Siren lacertina* stomachs containing the three major dietary categories in each study year.

Study Year	Empty	Plant	Animal	Total
1	2	25	21	33
	6.1%	75.8%	63.6%	
2	2	13	13	17
	11.8%	76.5%	76.5%	
3	3	12	13	18
	16.7%	66.7%	72.2%	
TOTAL	7	50	47	68
	10.3%	73.5%	69.1%	

from Florida. He concluded that mature individuals (≥350 mm. SVL) move into shallow water and congregate for breeding in February and March. Fertilization probably is external and females may guard the eggs. Young (15-20 mm. total length) first appeared in late April and early May and attained a SVL of about 75 mm. by mid-October.

92. Figure 12 shows the size distribution of all Siren lacertina collected on Lake Conway along with assignment of tentative year classes. In this sample the smallest individuals (55-66 mm. SVL) appeared in July and seemed to attain a SVL of 150 mm. by March at about one year of age. By March of their second year these individuals averaged about 250 mm. SVL, and perhaps 350 mm. by three years of age. Gonadal examination of 28 female and 38 male S. lacertina from Lake Conway provided limited information about size at sexual maturity. Critical samples of 350-400 mm. SVL animals during the reproductive season (late winter-early spring) were absent. Only two reproductive females were collected during the study: a gravid, 405 mm. SVL female taken in late-January and a spent female (450 mm. SVL) taken in mid-May. Male testes seem to enlarge in fall, reach maximum size in December, and regress by March. Ultsch (1973) found that 520 g. females were reproductive, suggesting that the minimum size of reproduction for females is 350 mm. SVL; the same may apply to males. If this is true, then reproduction probably occurs first at three years of age. One captive S. lacertina grew from about 234 mm. SVL to 637 mm. in 4.5 years ($\bar{X}$=89.3 mm./yr.) (Goin 1961). The species is known to live at least 25 years in captivity (Nigrelli 1954).

AMPHIBIA: ANURA

93. As is true of most freshwater ecosystems, frogs were an important and conspicuous element of the Lake Conway herpetofauna, accounting for 45.98% of the total observations (Table A2). Nine species representing four families were present: Bufo terrestris (Bufonidae), Acris gryllus, Hyla cinerea, H. femoralis and H. squirella (Hylidae), Gastrophryne carolinensis (Microhylidae), Rana grylio and R. utricularia (Ranidae).

94. The loud and characteristic vocalization of calling males provided a convenient means of monitoring adult frog populations. In addition, anuran

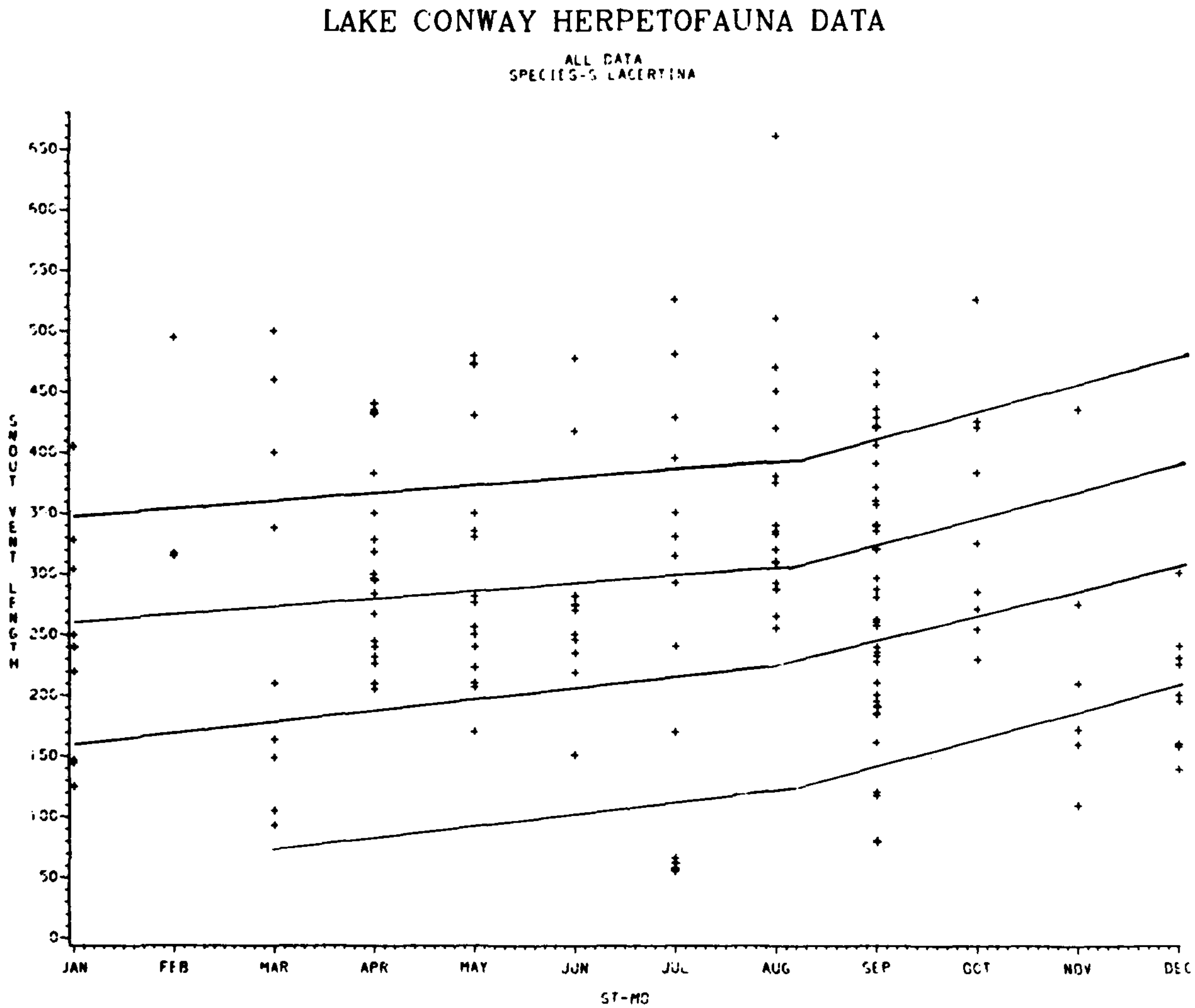

Figure 12. Monthly size class distribution of <u>Siren lacertina</u> with assigned year classes.

larvae were monitored with funnel traps. Beginning in April 1978, all tadpoles collected in traps were staged (Gosner 1960) to obtain populational estimates of developmental rate and larval lifespan. However, several aspects of frog ecology on Lake Conway (e.g., habitat selection in females and non-vocalizing males, survivorship of adults and larvae, food habits, growth) remain poorly known, and our coverage of these subjects is brief.

Bufo terrestris (Southern toad)

Distribution and Habitat Preferences

95. Southern toads were common along the shores of all the pools of the Lake Conway complex and accounted for 13.7% of the total anuran sample (Table A2). However, B. terrestris was relatively uncommon on the permanent sites where individuals made up only 1.5% of the calling frogs (Table A6) and 2.2% of the total frog sample (Table A3). Toads did not occur on the East Pool islands (Table A3). Because the species was rather poorly represented on the permanent sites a special effort was made to note choruses heard off these sites. As a result 31 additional B. terrestris choruses were recorded on nights when males of the species were not calling on a permanent site.

96. Bufo terrestris was common on the lawns and beaches that surround much of Lake Conway. In these habitats days were spent burrowed in the substratum and warm nights spent foraging for surface insects. During the breeding season males called from a variety of shoreline habitats. Shallows with little wave action seem to be preferred calling sites. B. terrestris was the only anuran species on Lake Conway known to call from white sand beaches but appeared to prefer low growing grasses (especially Panicum spp.). The use of beaches as calling sites may reflect the absence of more suitable habitat, i.e., most beach choruses occurred on long stretches of shoreline that contained no other habitat. Dense cattail beds and other tall, obstructive vegetation generally were avoided.

97. On the night of 25-26 July 1980 microhabitat selection was examined in a chorus of 86 B. terrestris calling from a mixed Panicum repens-Fuirena scirpoides bed along the shore of South Pool (coordinates 259, 193). Beach habitat surrounded this site on both sides. All members of the chorus were

collected. Table 10 categorizes the major habitats at this site and the density of toads in each. The highest densities were found in zones VI (F. scirpoides-P. repens) and II (bare mud). The toads located on bare mud probably were awaiting females to arrive at the chorus. Three amplectant females were found in the bare mud zone and another in zone IV. Of the three clutches of eggs located the following day, one clutch was in zone II and two were in zone IV. Of the 79 individuals observed in the water the mean distance from the shoreline was 1.77 m. (2SE=0.28, range=0.2-4.6 m.).

Activity Patterns

98. Bufo terrestris was recorded calling on permanent sites from March through August (Fig. 13). The absence of observations on permanent sites in June reflects the spotty distribution and explosive nature of Bufo choruses rather than a lack of calling activity on the lake system. Off-site records (N=31) expand the range of calling dates on Lake Conway from 21 February through 24 September with two different callings records in February, one in March, six in April, two in May, four in June, nine in July, four in August, and three in September. The seasonal distribution of calling activity by Bufo terrestris varied by study year on the permanent sites (Fig. 14). In different pools in different years calling peaked either in spring or summer.

Population Demography

99. Figure 15 shows the size frequency distribution of 86 adult B. terrestris collected from the South Pool chorus discussed previously. The mean size of 81 males was 58.5 mm. SVL (2SE=1.00, range=48-65 mm.); the five females averaged 73.8 mm. SVL. Males were amplectant with four of the five females. The mean SVL of these males (61.8 mm.) was slightly greater than non-amplectant males (58.3 mm.). The observed skewed sex ratio is typical of toad choruses since few females come to the water each night to breed (Christein and Taylor 1978, Gatz 1981).

100. No significant differences in the mean calling rates of B. terrestris between sites or between study years were detected (Table A5); the same was true when only the breeding season was considered (Table A6).

Reproduction and Growth

101. Little is known about growth and reproduction in B. terrestris on Lake Conway other than calling activity. No tadpoles were collected in funnel

Table 10

Habitat analysis of *Bufo terrestris* calling along the shore of South Pool (coordinates 259, 193) on the night of 25-26 July 1980. RR = *Panicum repens*, FS = *Fuirena scirpoides*.

Zone	Plant species	$\bar{x}$ % coverage	$\bar{x}$ Water depth (cm.)	Total area (m.^{2})	No. toads	Toads per m.^{2}
I	mowed lawn	5%	0	260.00	7	0.027
II	bare mud	0%	5	26.68	21	0.887
III	PR	95%	12	34.40	15	0.436
IV	PR	50%	30	21.60	12	0.555
V	FS, PR	15%	8	9.76	15	0.650
VI	FS, PR	30%	12	16.48	16	0.971

LAKE CONWAY HERPATROL RESULTS FOR EACH MONTH

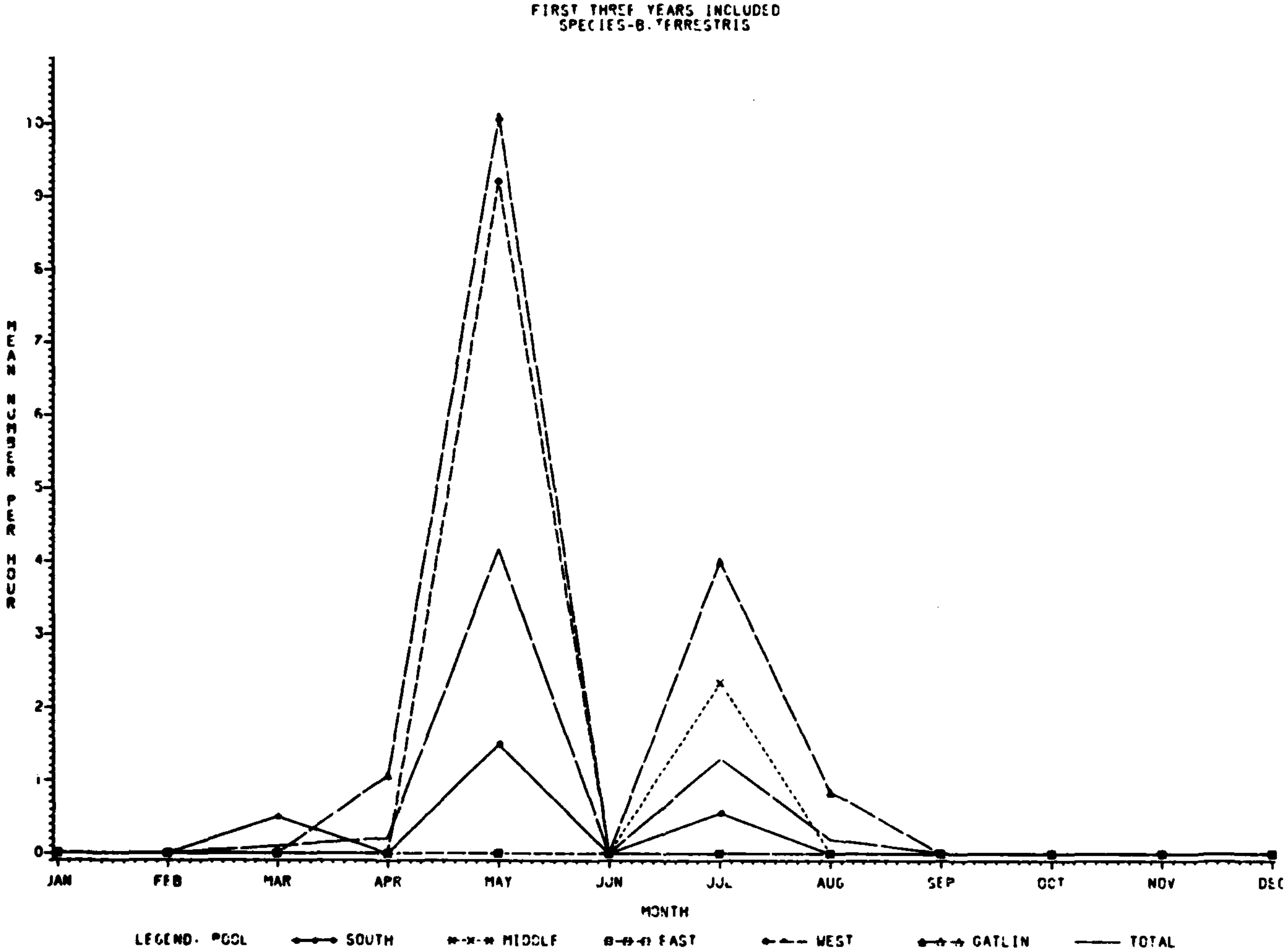

Figure 13. The mean number of Bufo terrestris calling per hour in each month on permanent sites during the three-year study.

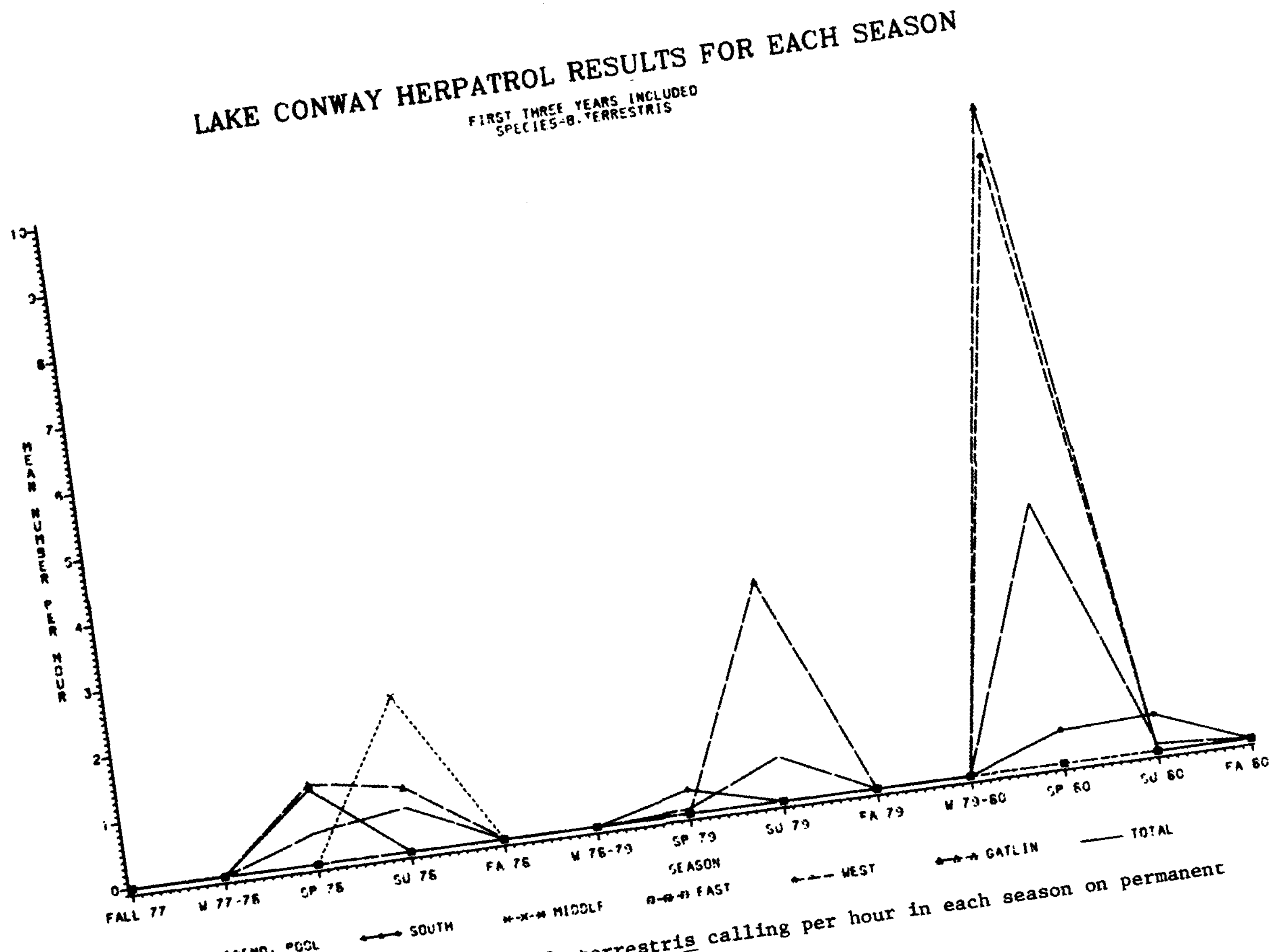

Figure 14. The mean number of <u>Bufo terrestris</u> calling per hour in each season on permanent sites during the three-year study.

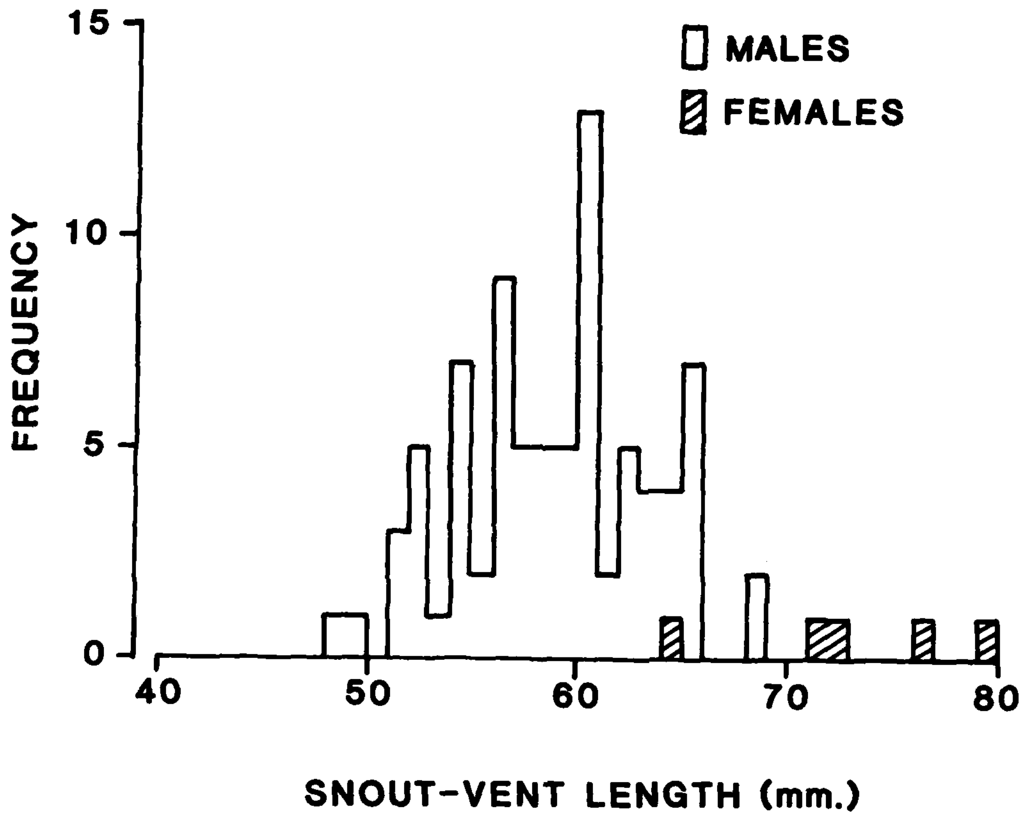

Figure 15. The size frequency distribution of Bufo terrestris collected on South Pool 25-26 July 1980.

traps but schools of approximately 300 and 100 tadpoles were observed on two occasions in Gatlin Canal. Three clutches of _B. terrestris_ eggs were found on 26 July 1980 at the South Pool chorus site. Southern toads typically deposit 2500-3000 eggs per clutch which hatch in 2-4 days; metamorphosis occurs 30-55 days later (Wright and Wright 1949).

Acris gryllus (Florida cricket frog)

Distribution and Habitat Preferences

102. Cricket frogs were the second most abundant anuran on Lake Conway, accounting for 23.20% of the total frog sample (Table A2) and 26.95% of the adult frogs recorded on permanent sites (Table A3). Among the permanent sites the species was most abundant in South, Middle and East Pools with few individuals recorded in West Pool and Gatlin Canal (Table A3).

103. At Lake Conway _Acris gryllus_ was most commonly seen along shore margins with an abundance of low growing grasses (especially _Eleocharis_ spp.) or perched on mats of floating hydrophytes. Cricket frogs were rarely observed more than 1 m. from water and typically escaped by hopping into the water and submerging. White sand beach was the only habitat on Lake Conway clearly avoided by _A. gryllus_. Figures 9, 10, and 11 of McDiarmid et al. (1983) graphically showed the effects on _A. gryllus_ of shore line development and conversion of native habitats to beach on the South Pool permanent site. At this site cricket frogs called from 42 stations in SY1 and 40 stations in SY2; with most of the shoreline developed by SY3 the species was restricted to 23 stations divided into four relatively undisturbed patches.

104. Microhabitat information was collected for 22 _A. gryllus_ on the South Pool site during the night of 25 July 1980. At calling sites total percent cover averaged 64.3% (2SE=11.24, range=12-99%). The mean number of plant species within 1 $m.^2$ quadrats for the 22 _A. gryllus_ capture points was 10.1 (2SE=1.04, range=5-15). In order of decreasing abundance the most common dominant plant species in these quadrats were _Hydrocotyle umbellata_ (8 quadrats), _Eleocharis baldwinii_ (5), _Fuirena scirpoides_ (5), _Lachnanthes caroliniana_ (3) and _Bacopa monnieri_ (1).

Activity Patterns

105. On Lake Conway *A. gryllus* called from February through September with a general peak in mid-summer (Fig. 16). Between-site differences in the month of peak calling activity were primarily due to variation between years (Fig.17). In SY1 and SY2 mean calling activity was highest in summer at all sites except Middle Pool; but in SY3 calling in South, Middle and West Pools peaked in fall (specifically September).

Population Demography

106. During the night of 25 July 1980, 27 *Acris gryllus* were captured and 18 were measured. The mean SVL of 15 adult males was 20.7 mm. (range=19-23 mm.), one female was 24 mm. and two juveniles each measured 7 mm.

107. The mean number of male *Acris gryllus* heard calling per hour varied significantly between study sites in all years (Tables A5, A6). During the breeding season (Table A6) South and East Pools had the highest calling activity, followed by Middle, Gatlin and West Pools. This rank-order of sites did not vary with study year. No significant between-year differences were detected, either within or between sites.

Growth and Reproduction

108. Only a single *Acris gryllus* larvae (stage 25) was collected. This specimen was taken in a funnel trap in Middle Pool in July (Table A1). Females are known to deposit clutches averaging 250 eggs from February to October; the tadpoles metamorphose in 50 to 90 days (Wright and Wright 1949: 219-220).

Hyla cinerea (Green treefrog)

Distribution and Habitat Preferences

109. *Hyla cinerea* was the most commonly recorded anuran on Lake Conway, accounting for 44.99% of the total frog observations (Table A2) and 53.65% of the total number of adult frogs recorded on permanent site herp-patrols (Table A5). Of the 2,460 individuals recorded from permanent sites (Table A3), most (42.56%) were from West Pool followed by East Pool (26.63%), Gatlin Canal (16.50%), Middle Pool (10.98%), and South Pool (0.33%).

110. At permanent sites *H. cinerea* called from a variety of vertical perches and was most abundant in stands of cattail (*Typha latifolia*), pickerel

LAKE CONWAY HERPATROL RESULTS FOR EACH MONTH

FIRST THREE YEARS INCLUDED
SPECIES-A.GRYLLUS

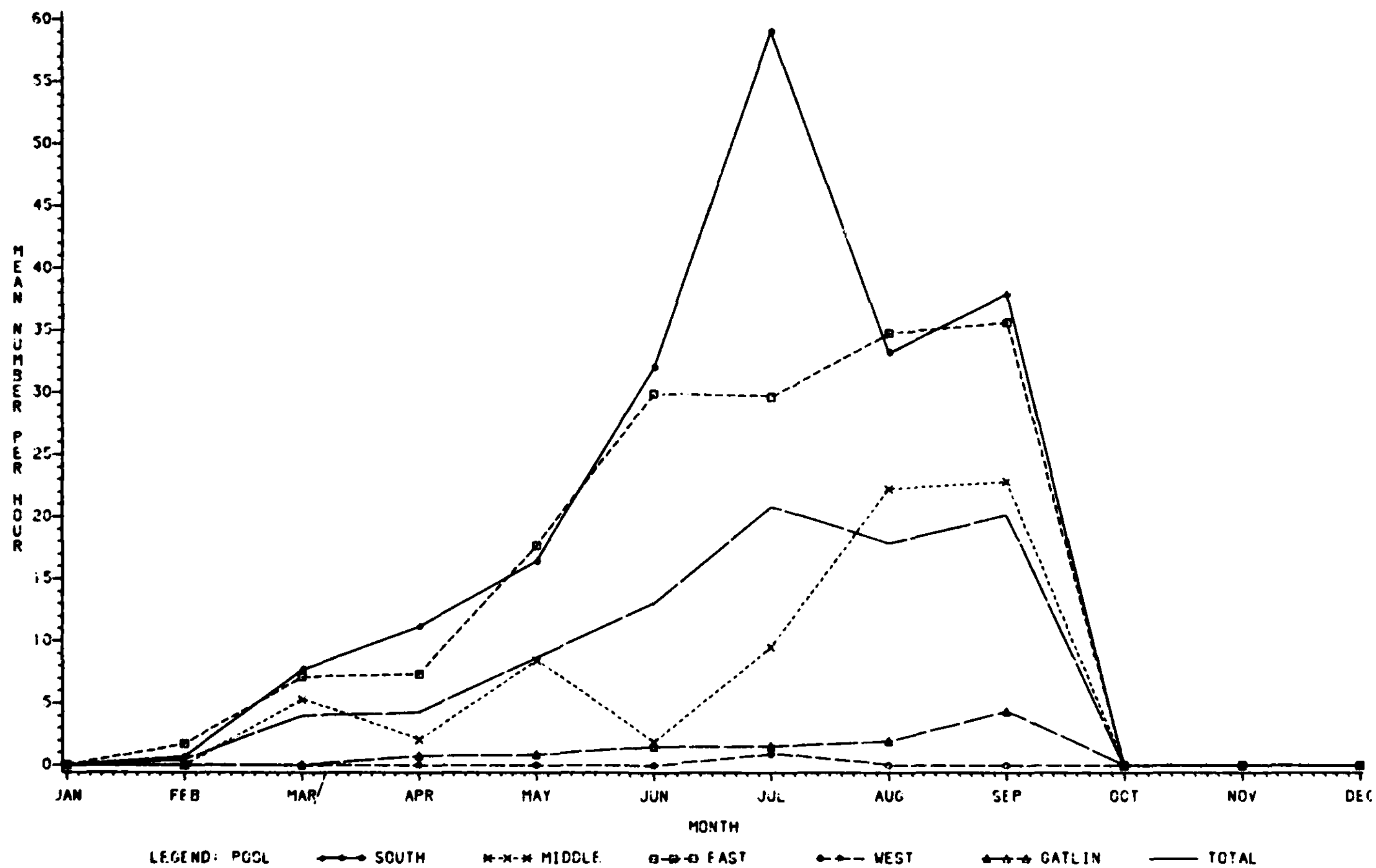

Figure 16. The mean number of Acris gryllus calling per hour in each month on permanent sites during the three-year study.

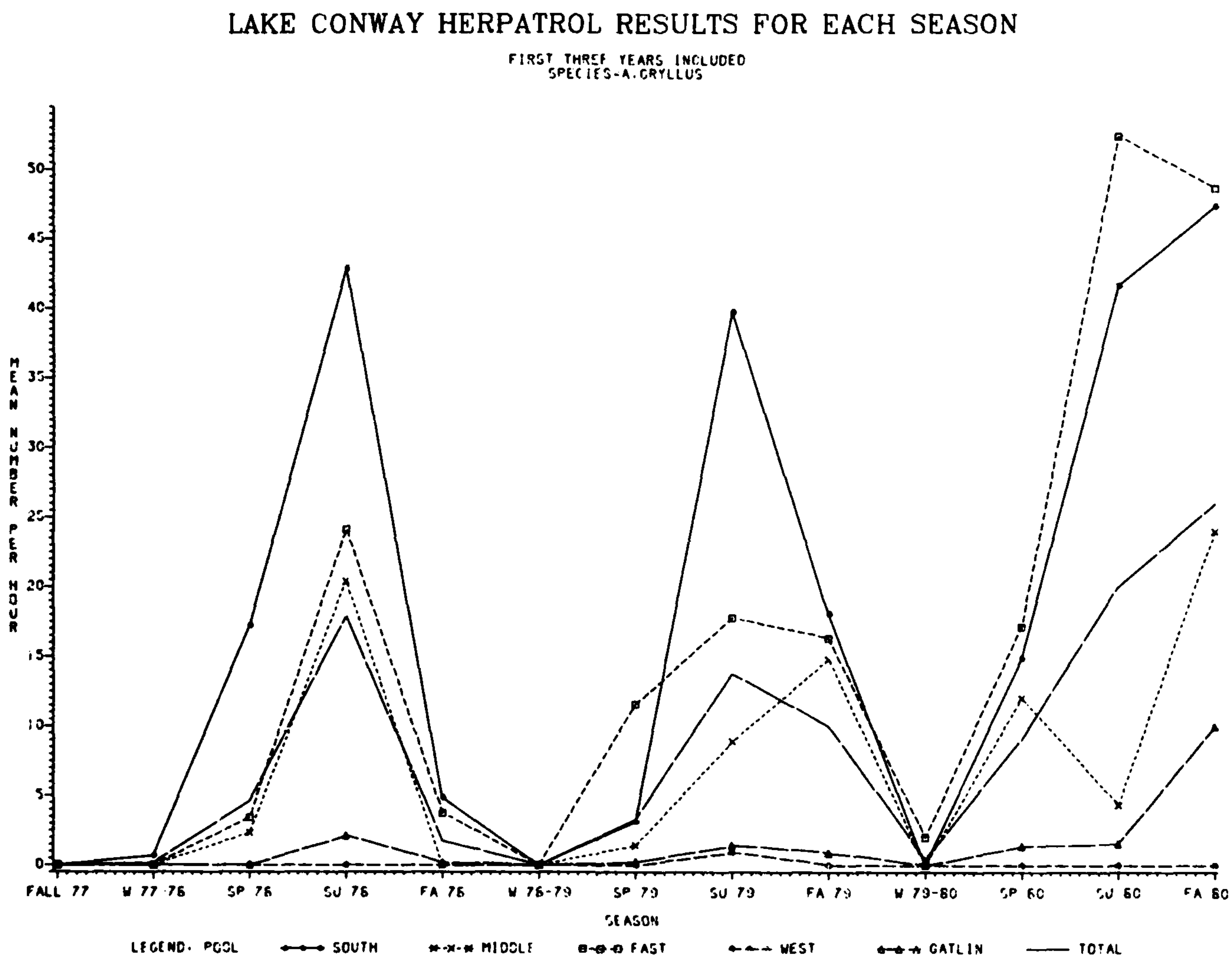

Figure 17. The mean number of <u>Acris gryllus</u> calling per hour in each season on permanent sites during the three-year study.

weed (Pontederia lanceolata) and waterhyacinth (Eichhornia crassipes). Bare sand beaches were avoided. These habitat preferences were apparent in the community figures provided in McDiarmid et al. (1983).

111. Detailed microhabitat information was available for nine H. cinerea from the East Pool site and for 30 individuals from the West Pool site on the night of 26 July 1980. At the East Pool site, samples were taken along a 20 m. stretch of shoreline between markers 140 and 160. At this location, primrose (Ludwigia peruviana) lined the bank followed by a 10-15 m. band of waterhyacinths which was skirted offshore by a narrower (2-5 m.) band of cattail intermixed with waterhyacinths. All H. cinerea (N=9) were calling on waterhyacinth even though cattail occurred in three of the 1 $m.^2$ quadrants. The average distance from shore for the 9 specimens was 12.7 m. (range=9.0-15.0 m.). Water depth varied from 0.4 to 1.0 m. ($\bar{X}$=0.6 m.). Total percent vegetative cover at these calling sites ranged from 80 to 98%.

112. Microhabitat information for H. cinerea on the West Pool permanent site was collected between markers 120 and 140 in a more heterogeneous, marshy area which historically produced large choruses (see Fig. 33 in Godley et al. 1981; Figs. 45, 46, and 47 in McDiarmid et al. 1983). The mean distance from shore of 30 individuals was 8.5 m. (range=3.0-14.0 m.) and water depth averaged 0.27 m. (range=0.1-0.5 m.).

113. Table 11 summarizes plant microhabitat information for the West Pool sample of H. cinerea. In 27 1 $m.^2$ quadrats where the 30 H. cinerea were located, the number of plant species ranged from 3 to 8 ($\bar{X}$=5.81). H. cinerea called from six of these species. Collectively these species accounted for 86.1% of the total plant cover available in the quadrats and were the dominant species. To determine if green treefrogs were selecting specific plant species as calling sites the percent cover of these dominant plant species averaged over all quadrats was compared with the observed frequency distribution of H. cinerea (Table 11). The analysis is both conservative and biased because it included only quadrats in which frogs were calling. Even with these limitations the results suggest a non-random distribution of frogs on plant species (Table 11). Typha latifolia contributed most to chi-square and apparently was preferred as a calling site. The mean height above water of calling H. cinerea also varied with plant species and probably reflected the

Table 11

Habitat analysis of 30 *Hyla cinerea* calling within 27 1 $m.^2$ quadrats between markers 120-140 of the West Pool permanent shoreline site on 27 July 1980. Frequency of occurrence is the percentage of quadrats in which a plant species occurred; mean percent cover is the average contribution of the plant species to total vegetative cover within the quadrats. The expected distribution of frogs on a plant species was calculated by multiplying the mean percent cover of a species times the total number of frogs observed. *P. lanceolata* and *S. lancifolia* were lumped because the expected distribution was less than 5.

Plant availability within quadrats	*Eichhornia crassipes*	*Ludwigia peruviana*	*Pontederia lanceolata*	*Sagittaria lancifolia*	*Salvinia rotundifolia*	*Typha latifolia*
Frequency of occurrence	24.60%	22.23%	2.47%	6.17%	20.98%	23.46%
Mean % cover	38.93%	22.20%	0.26%	4.09%	17.93%	16.59%
Frog distribution within quadrats						
Number of individuals	9	6	1	2	2	10
Expected distribution	11.67	6.66	1.31		5.38	4.98
Chi-square	0.61	0.07	2.20		2.12	5.06
Mean height above water (cm.) (range)	23.1 (3-42)	68.2 (45-100)	50.0 (50)	62.5 (5-120)	0 (0)	47.3 (3-90)
Mean stem/leaf diameter (cm.) (range)	5.0 (1.2-7.5)	3.0 (1.3-413)	3.0 (3.0)	8.0 (7.0-9.0)		2.0 (1.5-3.2)

availability of suitable perch sites on the plant. For example, at this location *Eichhornia crassipes* rarely grew taller than 0.5 m. and the mean height of *H. cinerea* on waterhyacinth (23.1 cm.) was relatively low. *Salvinia rotundifolia* forms a mat on the water's surface from which frogs occasionally called. The other plant species were comparatively tall and *H. cinerea* calling sites were correspondingly higher. Analysis of stem/leaf diameters for the various plant species suggest that *H. cinerea* requires a perching surface of at least 1.2 cm. width.

114. Although admittedly superficial the above analysis does characterize the breeding sites of *H. cinerea* on Lake Conway. Relatively dense, upright vegetation was required for successful reproduction. Loss of this habitat by the actions of either man or white amur would result in extirpation of *H. cinerea* from the site.

Activity Patterns

115. Like most other frogs on Lake Conway *H. cinerea* displayed a "summer" breeding pattern and called from April through September (Fig. 18). Peak calling activity typically occurred during the months of July and August when daily thundershowers were common. Analysis of seasonal breeding activity through the study years showed considerable variation between sites (Fig. 19). For example, calling activity on the East Pool site was lower during the summer of 1979 than during other years but West Pool showed no such reduction.

Population Demography

116. The snout-vent length of 31 male *H. cinerea* found calling on the East and West Pool sites ranged from 37 to 51 mm. ($\bar{X}$=45.7 mm., 2 SE=3.04). Two females collected at these sites were 50 and 51 mm. SVL. These sizes are typical of adult *H. cinerea* in Florida (Wright and Wright 1949, Duellman and Schwartz 1958).

117. Significant between-pool differences in the calling activity of *Hyla cinerea* were detected for both the entire year (Table A5) and for the breeding season only (Table A6). In general, densities were high in East and West Pools, moderate in Middle and Gatlin, and low in South Pool. These differences probably reflect between-site variation in habitat quality. No statistically significant between-years differences in calling activity were detected.

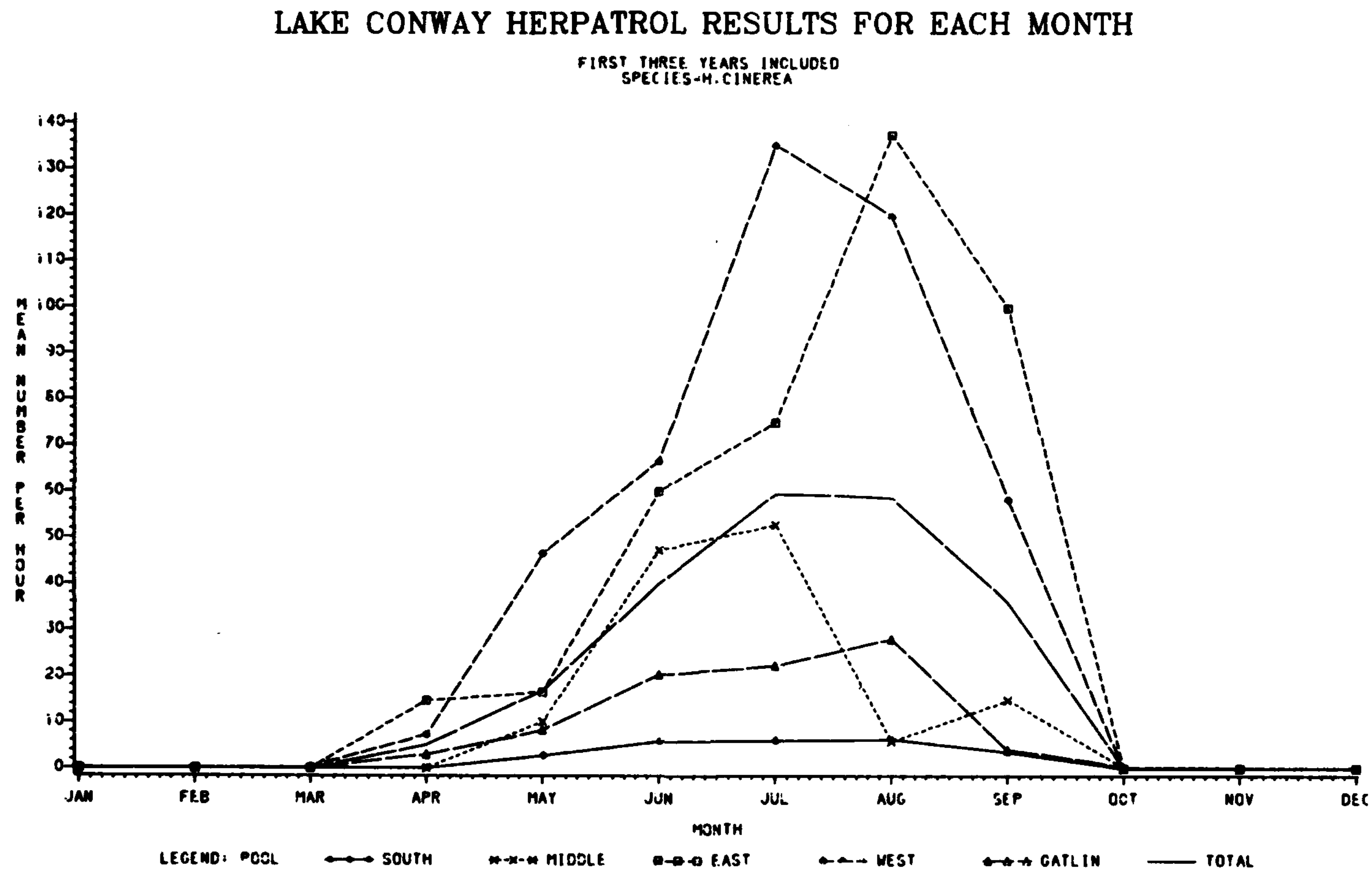

Figure 18. The mean number of <u>Hyla cinerea</u> calling per hour in each month on permanent sites during the three-year study.

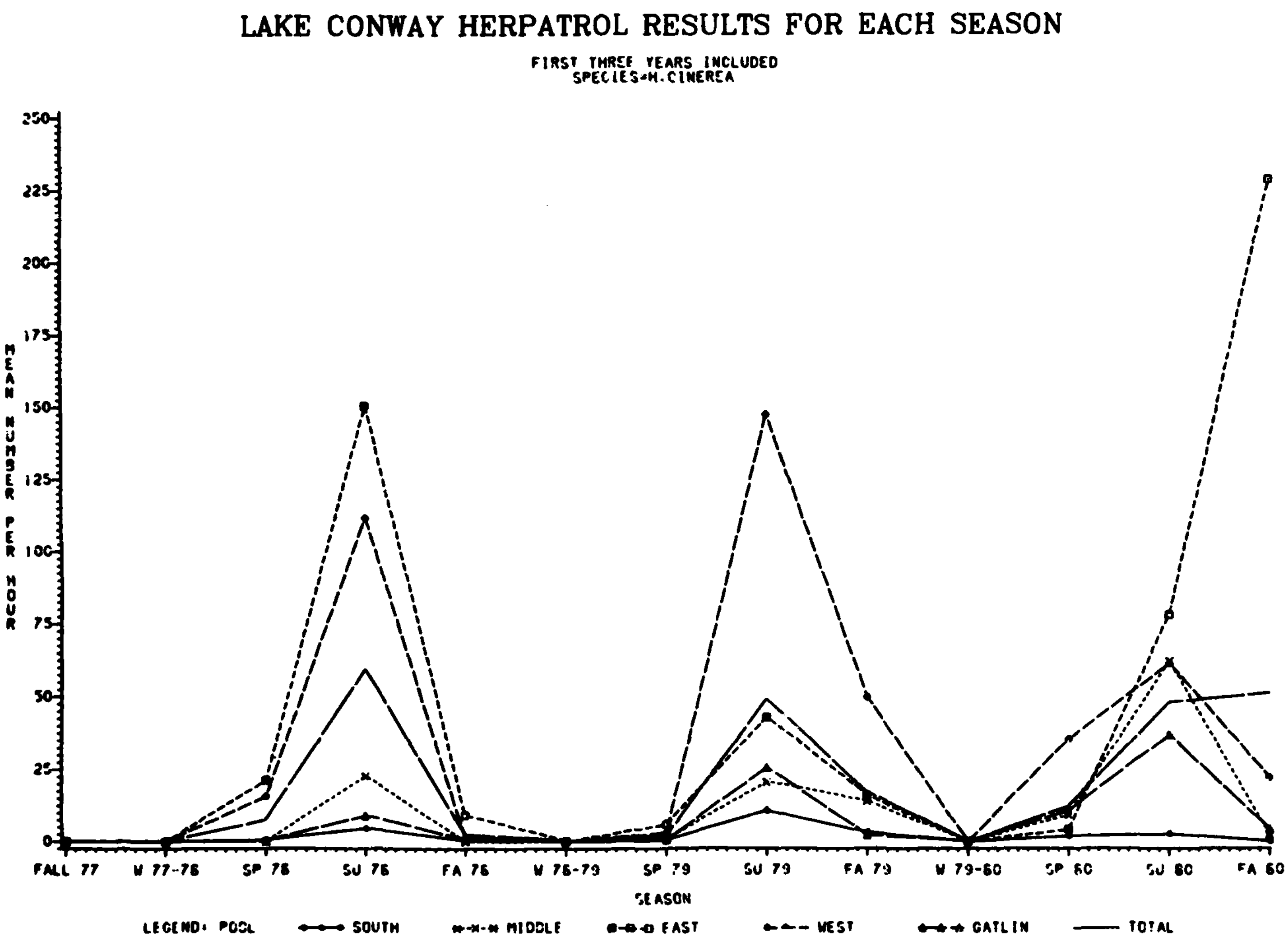

Figure 19. The mean number of Hyla cinerea calling per hour in each season on permanent sites during the three-year study.

Growth and Reproduction

118. No information concerning growth rates of *Hyla cinerea* on Lake Conway is available. Tadpoles are known to metamorphose from July to October after a larval period of 55 to 63 days (Wright and Wright 1949:306).

Hyla femoralis (Pinewoods treefrog)

119. *Hyla femoralis* was the rarest frog species on Lake Conway. Only four individuals were recorded during the study (Table A2); these individuals were heard calling from a small temporary pond about 200 m. east of the Middle Pool site on 16 August 1978. Shortly thereafter this pond was bulldozed over and filled for a housing development. The species was not heard again on Lake Conway.

120. As its common name implies, *H. femoralis* is most abundant in pine flatwoods habitat where it breeds in intermittant marshes and temporary ponds during the summer rainy season (Wright and Wright 1949). Because the species rarely breeds in permanent bodies of water, it probably never was common on Lake Conway. Loss of the pinelands which once surrounded portions of the lake removed the only other suitable habitat for the species.

Hyla squirella (Squirrel treefrog)

121. *Hyla squirella* was recorded from only the South Pool permanent site on Lake Conway (Table 2); 17 individuals were heard calling during the summers of SY1 and SY2 (Table A3 and Fig. 14 of McDiarmid et al. 1983). On the South Pool site most individuals called from vegetation overhanging a ditch that drained a small pond near marker O (see Figs. 9 and 10 in McDiarmid et al. 1983); other individuals from along this site were heard some distance from the shore, giving their characteristic "rain call" from surrounding vegetation and window sills of houses.

122. Like its congener *Hyla femoralis*, the preferred breeding sites of *H. squirella* are temporary ponds or marshes, often in mesic wooded areas (Carr 1940, Wright and Wright 1949). This preference for ephemeral breeding sites probably explains the rarity of *H. squirella* on Lake Conway. On the South Pool

site H. squirella apparently breed in the ditch near marker 0; flow into the ditch was intermittant and the ditch sometimes dried during the spring. This ditch was cleared of vegetation during SY3 which eliminated the only known breeding site for this species on South Pool.

Gastrophryne carolinensis (Eastern narrow-mouthed toad)

Distribution and Habitat Preferences

123. Gastrophryne carolinensis accounted for 2.95% of the total observations for frogs and was recorded from all pools except East Pool (Table A2). Like Bufo terrestris, G. carolinensis did not occur on the East Pool islands and thus was not recorded from the East Pool permanent site (Table A3). However, narrow-mouthed toads were heard calling from the western shores of East Pool.

124. Little is known about the habitat preferences of this small, secretive frog species on Lake Conway. During the non-breeding season the species is semi-fossorial and prefers moist, shaded habitats where it typically feeds underground, often on ants (Carr 1940; Anderson 1954). Several specimens were found under boards along the shores of Lake Conway. During the breeding season males call from wet, grassy sites along the shores of a variety of different aquatic habitats (see review in Nelson 1972). On Lake Conway the species was most abundant on the West Pool site (Tables A5, A6), and marked habitat preferences for calling sites were recorded at this site (see Fig. 45, 46, and 47 of McDiarmid et al. 1983). In all years calling activity was concentrated in three sections of the site (between markers 90-170, 210-240, and 270-350) which accounted for 59.4% of the site but 83.3% of the vocalizations. These favored calling sites were characterized by dense underbrush and grassy borders near the shoreline. Beach habitat which comprised 18.9% of the West Pool site accounted for only 0.8% of the records, suggesting that G. carolinensis avoids sandy, exposed areas as calling sites.

Activity Patterns

125. On Lake Conway G. carolinensis called from May through September (Figure 20). The apparent bimodal peak (June and September) for the West Pool site was the result of one sampling trip on 4 September 1980, when the recorded

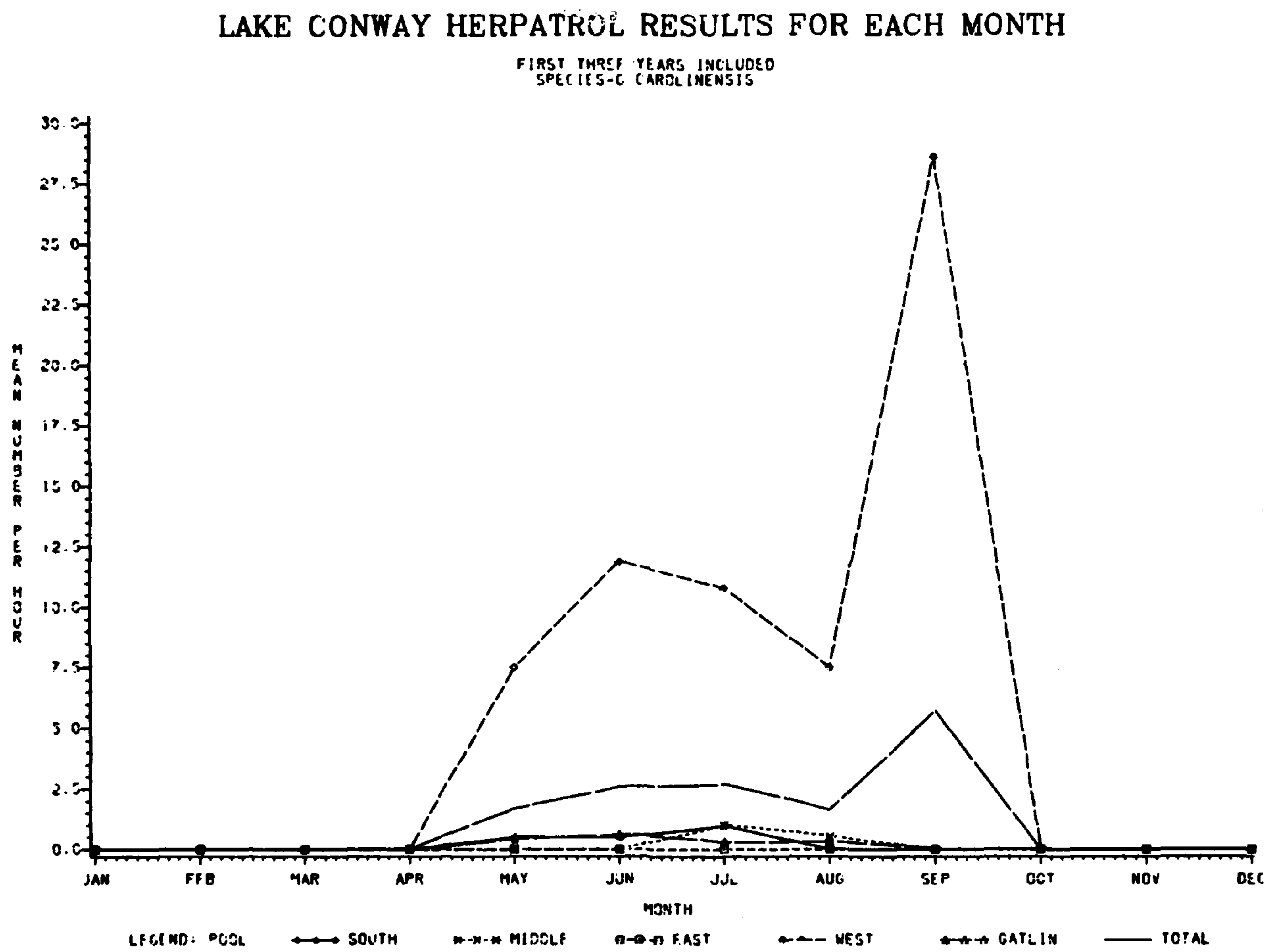

Figure 20. The mean number of Gastrophryne carolinensis calling per hour in each month on permanent sites during the three-year study.

relative density of _G. carolinensis_ was 107.8 per hour. This fall peak was not observed in other years (Fig. 21).

Population Demography

126. Table A5 compares the relative density of calling male _G. carolinensis_ between years and between permanent shoreline sites for the entire year and Table A6 presents a similar analysis for the breeding season only (April through September). When the entire year was considered (Table A5) no significant differences occurred betweeen years or between sites. However, during the breeding season (Table A6) significant site differences were detected with densities generally averaging higher in West Pool than at all other sites. No significant between-year variation in calling activity was detected. Nothing is known about demographic parameters of narrow-mouthed toad populations on Lake Conway.

Growth and Reproduction

127. Other than calling activity, little is known about reproduction in _Gastrophryne carolinensis_. Clutch size typically averaged 850 eggs and the tadpoles transformed after a period of 20 to 70 days (Wright and Wright 1949).

Rana grylio (Pig frog)

Distribution and Habitat Preferences

128. Pig frogs were the fifth most abundant anuran on Lake Conway, accounting for 5.0% of the total anuran sample (Table A2) and for 4.9% of the frogs recorded calling on herp-patrols (Table A5). _R. grylio_ was the only adult anuran regularly captured in funnel traps with 18 of 234 total individuals taken by this method (Table A1). A total of 56 _R. grylio_ tadpoles also was taken by funnel traps and drift fences (Table A1).

129. _Rana grylio_ was the only common anuran species that did not occur in South Pool (Table A2). By the time this study had begun, all potentially suitable habitat for _R. grylio_ on South Pool had been converted to beach frontage. Among permanent shoreline sites (Table A3) adult pig frogs were most commonly recorded in Middle Pool (N=76), followed by Gatlin Canal (73), East (56), and West Pool (17). Most (41 of 58) tadpoles were collected in Middle Pool (Table A3), but these data are biased since 75.6% of those were taken in

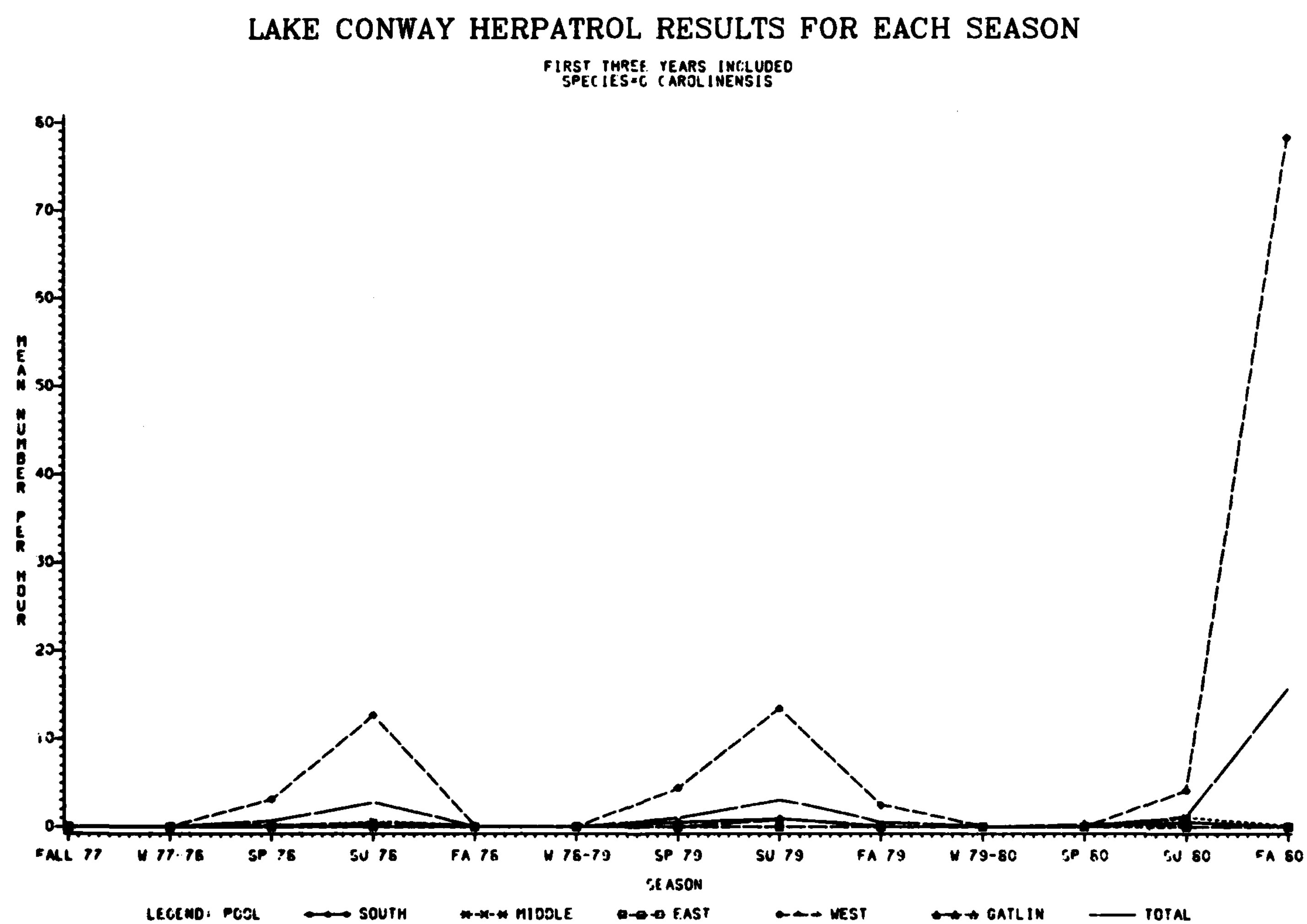

Figure 21. The mean number of Gastrophryne carolinensis calling per hour in each season on permanent sites during the three-year study.

an aquatic drift fence which was set only in this pool during SY1 (Godley et al. 1981).

130. Little is known of the specific habitat requirements of R. grylio on Lake Conway. Pig frogs are extremely difficult to localize and approach while calling; thus it was not feasible to gather specific microhabitat information for calling males. The species is highly aquatic (Carr 1940, Wright and Wright 1949); on Lake Conway none was observed on land. Favored habitat of adults appeared to consist of dense marshes composed of Typha latifolia, Eichhornia crassipes, and Pontederia lanceolata such as were available on the Middle and East Pool permanent sites. In Gatlin Canal pig frogs also were common in the thick, floating mats of Panicum repens which lined much of the bank. The few individuals actually observed during herp-patrols were wedged between T. latifolia or P. lanceolata stalks or seen floating partially submerged on mats of aquatic vegetation, often several meters from shore.

Activity Patterns

131. Rana grylio was one of the few species of frogs commonly captured in funnel traps on Lake Conway (Table A1). During the first study year, when traps were checked at dawn and dusk, all six adults and nine of eleven R. grylio larvae were taken during daylight hours. Of the 18 transformed pig frogs collected in funnel traps (Table A1), four were taken in winter, two in spring, one in summer and eleven in fall (seven of these in September). Of the 25 tadpole R. grylio taken in funnel traps (Table A1), two were obtained in winter, five in spring, eight in summer (six of these in August) and ten in fall (9 in September).

132. On Lake Conway R. grylio exhibited a distinct June-July peak in calling activity (Fig. 22). However, unlike most other "summer" breeders, pig frogs had an extended calling season with some individuals vocalizing from early March through early November. Carr (1940) recorded breeding from 4 March to mid-September. On Lake Conway seasonal patterns of calling activity were consistent within study years but showed considerable between-year variation (Fig.23). Mean calling rates on the Gatlin Canal, Middle, and East Pool sites were much higher in SY3 than SY1 or SY2. However, on the West Pool site R. grylio was absent during SY1 and SY3 and, moderately common during SY2.

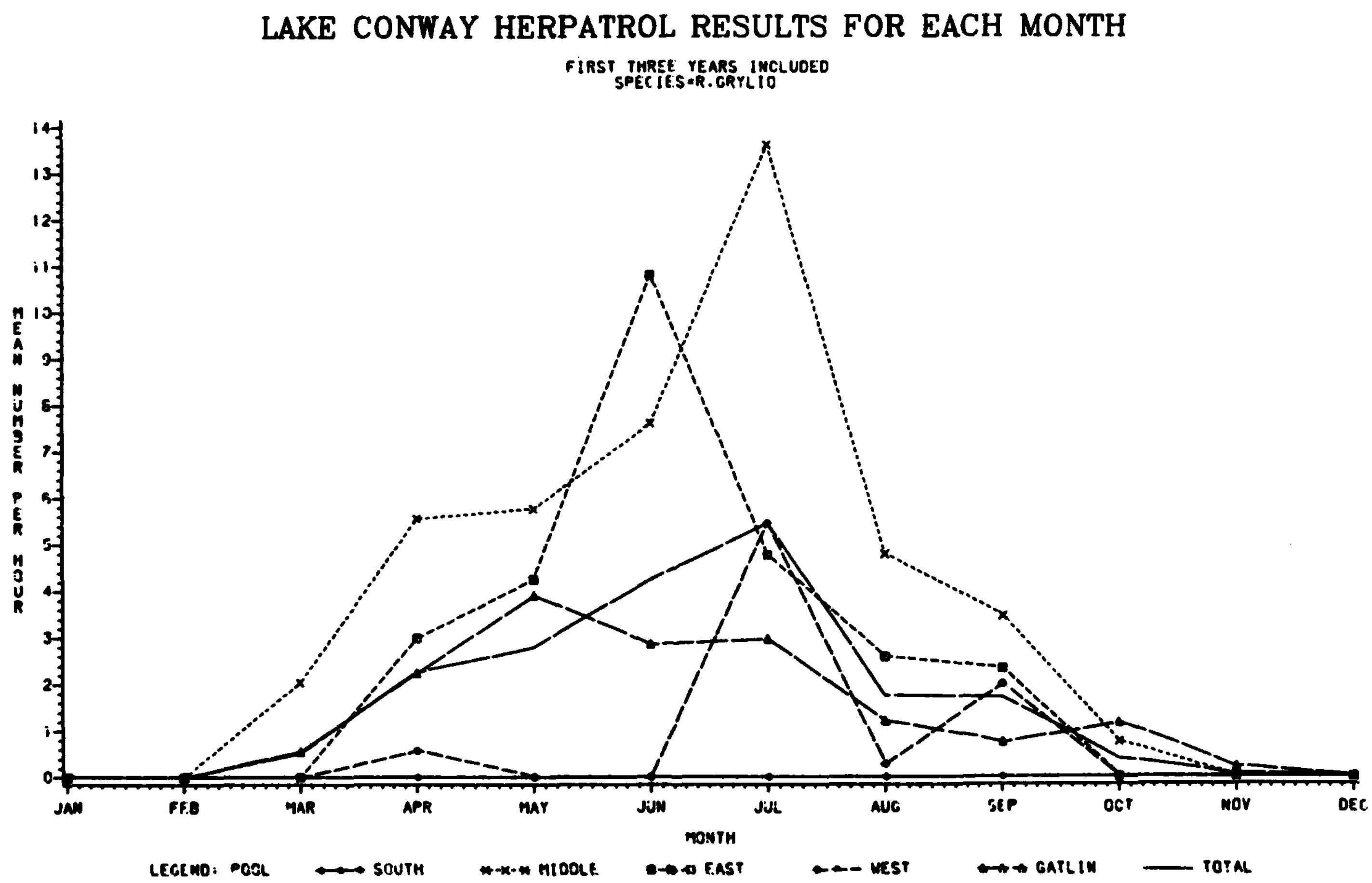

Figure 22. The mean number of Rana grylio calling per hour in each month on permanent sites during the three-year study.

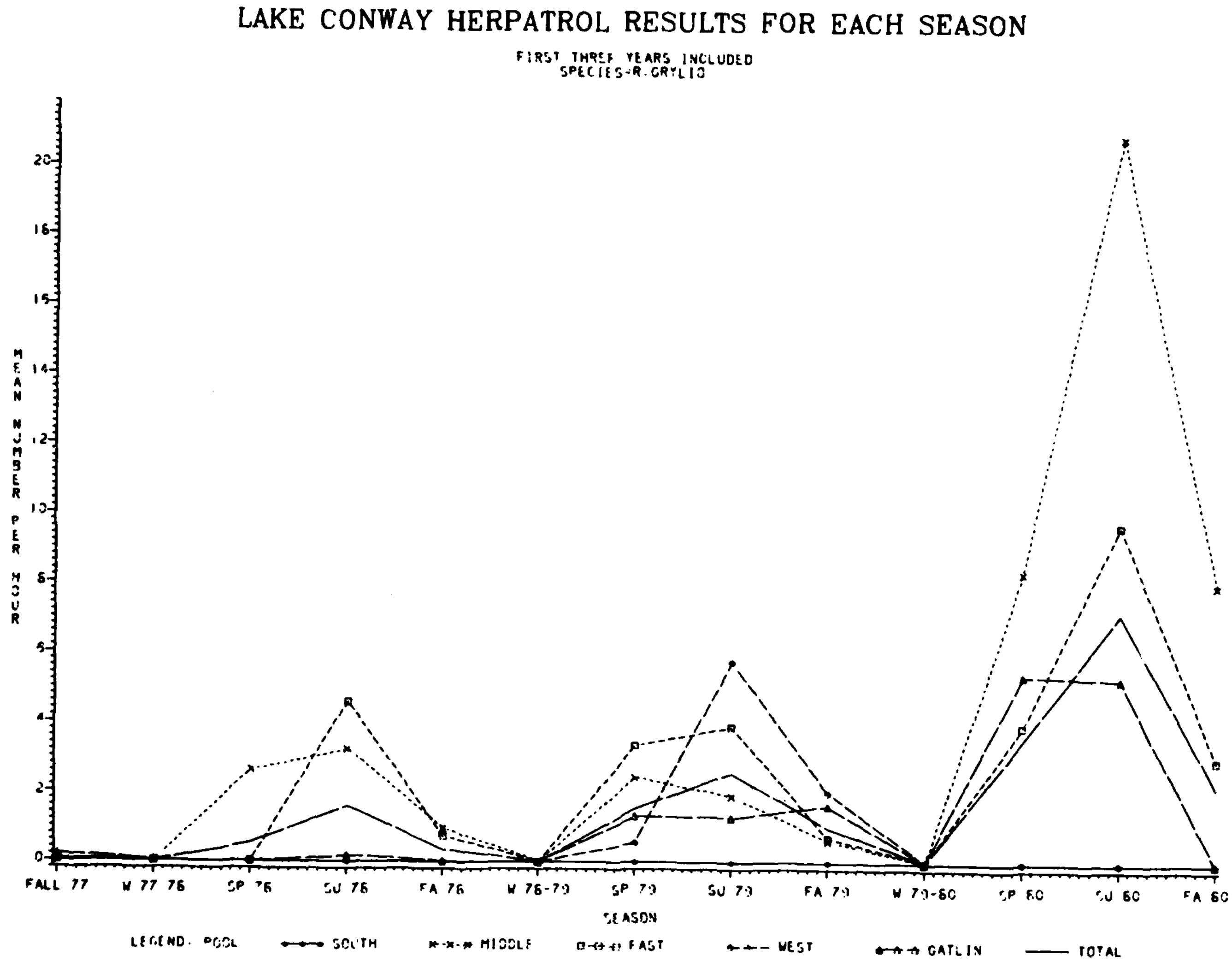

Figure 23. The mean number of Rana grylio calling per hour in each season on permanent sites during the three-year study.

Population Demography

133. The mean relative density of calling pig frogs showed significant between-site differences during SY3 and for all years combined but were not different in SY1 or SY2 (Table A5). When only the April-September breeding season was considered (Table A6), a similar pattern emerged but SY1 also showed significant between-site differences. *R. grylio* was absent from South Pool. In general, mean calling densities of *R. grylio* were lowest in West Pool and averaged higher in the other pools. This trend also held for funnel-trapped *R. grylio* adults and larvae (Table A4). These differences probably reflect subtle variation in habitat quality for *R. grylio* on the permanent sites.

134. *Rana grylio* was one of the species of anurans to show significant between-year variation in calling activity on the permanent sites (Tables A5, A6). The mean number of males recorded per hour increased in all pools in each study year except in South and West Pools. Pig frogs were absent in South Pool and were recorded from West Pool only in SY2 (Table A3). The yearly increases in calling activity (Table A5, A6) on the Middle, East, and Gatlin sites were not reflected in the mean yearly capture rates of either *R. grylio* adults or larvae in funnel traps (Table A4). The funnel trap results showed no consistent yearly patterns across pools, although the general trend is a reduction through time in capture rates of adults and larvae.

135. If calling activity and funnel trap captures are equally good indicators of population density, then concordance between the methods is expected. Breeding in frogs is tightly linked to weather conditions. Subtle yearly variation in weather could produce significant differences in calling activity that do not reflect real changes in density. The same may be true of funnel trap captures. At present, data are not available to evaluate the reliability of either sampling method as a predictor of population density.

Growth and Reproduction

136. *Rana grylio* captured in funnel traps provided some idea of the population structure of this species on Lake Conway. The snout-vent length of 18 transformed individuals ranged in size from 30 mm. to 123 mm. and the two largest individuals (121 and 123 mm. SVL) were males. Recently transformed individuals (30 to 70 mm. SVL) were most abundant in fall (6 to 11 captures) and winter (3 of 4) with none collected in spring or summer, suggesting that

metamorphosis occurs chiefly in late summer and fall.

137. A total of 56 R. grylio tadpoles from funnel trap and drift fence samples (Table A1) was staged according to Gosner's (1960) staging tables. In Gosner's tables the fertilized egg is stage 1, rear limb-buds emerge at stage 26, and metamorphosis is complete by stage 46. Figure 24 plots the monthly distribution of these 56 R. grylio tadpoles by developmental stage. The large sample in May was collected chiefly in the Middle Pool drift fence which was set only in April and May. Probably because of poor mobility, small tadpoles (stage 28 or lower) were rare in the sample but were most common from July through September. These individuals probably represented that years' reproduction, whereas larger tadpoles were assumed to be from the previous years. Wright (1932) reported that in Okefinokee Swamp, Georgia, R. grylio has a larval period of one, possibly two, years and metamorphosed from April through July. On Lake Conway it seemed that the larval period was typically one year and tadpoles transformed mostly in summer and early fall.

Rana utricularia (Southern leopard frog)

Distribution and Habitat Preferences

138. Southern leopard frogs accounted for 4.84% of the total observations on Lake Conway and were the third most frequently recorded frog species with 577 observations (Table A2). Most (97.76%) adults were recorded on herp-patrols and most (67.90%) larvae were taken in funnel traps (Table A1). Most records for adult R. utricularia were from Middle Pool (N=124), followed by Gatlin (123), West (105), South (90), and East (49) (Table A2). Larvae were taken primarily in Middle and East Pools but egg clutches were found only in South (N=1) and West (4) (Table A2). Permanent shoreline sites accounted for 99.4% of the adult records and all observations for egg clutches and larvae (Table A3).

139. Relatively little is known about microhabitat selection in Rana utricularia on Lake Conway. Carr (1940) suggested that they are ecologically the most widely distributed ranid frog in Florida. Perusal of the permanent site point analyses, figures, and site descriptions provided in McDiarmid et al. (1982) suggests the following generalizations: (1) White sand beaches were

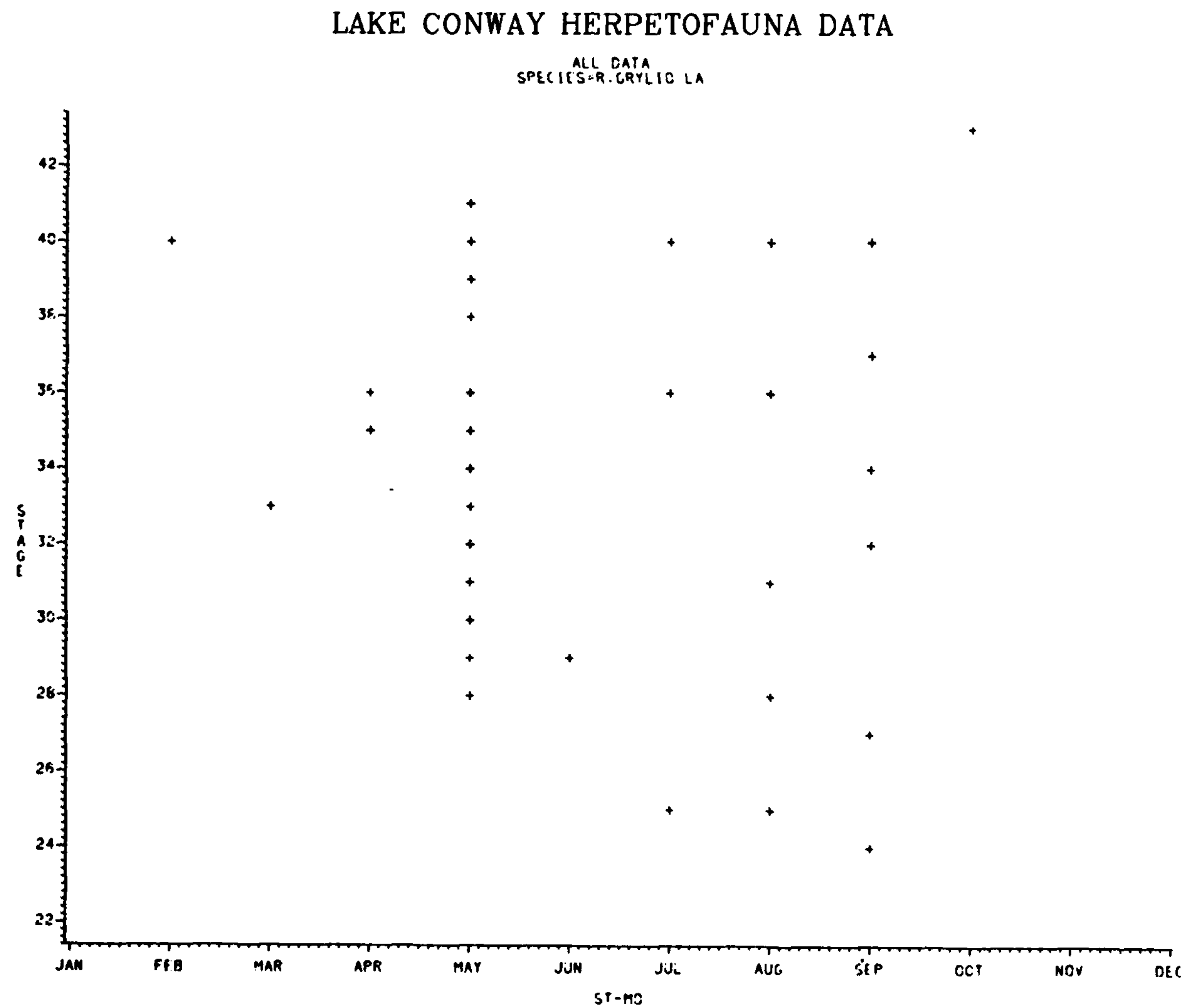

Figure 24. The monthly distribution of Rana grylio tadpoles staged according to Gosner (1960).

avoided. Avoidance of these barren stretches of shoreline is shown by the gradual constriction of R. utricularia calling sites on South Pool as this site was developed for houses (Figures 9-11), the near extirpation of this species from the disturbed section (points 1000-1120) of the Middle Pool site during SY2 (Fig. 22), and their remarkable recolonization of the Middle Pool section following the establishment of second-growth sedges and grasses in SY3 (Fig. 23). (2) Moderately dense patches of sedges (e.g., Fuirena scirpoides, Cyperus spp., Eleocaris spp.) and grasses (e.g., Andropogon spp.) bordering the shoreline seemed to be optimal habitat for R. utricularia on Lake Conway. Sections of shoreline supporting these plants generally had the highest densities of R. utricularia adults. This finding was confirmed by both point analyses and visual sightings of adults during shoreline censuses. (3) Tadpoles of R. utricularia occurred in a variety of habitats, but like adults avoided beaches. Most funnel trapped R. utricularia larvae were collected in habitats dominated by Pontederia lanceolata, Typha latifolia, or Eichhornia crassipes. (4) All five egg clutches of R. utricularia found on Lake Conway were attached to stems of Panicum hemitomon. Whether this plant species was preferred as an egg-laying site is unknown. Clearly this plant species was not required as R. utricularia breeds at sites where P. hemitomon was rare or absent.

Activity Patterns

140. Rana utricularia was the only anuran species to call every month of the year on Lake Conway (Fig. 25). As a result, the breeding season of this species is difficult to define. Carr (1940:68) believed that R. utricularia may breed every month of the year, Wright and Wright (1949:494) stated from February to December with a peak from April to August, and Brimley (1940:27) in February and March but occasionally in late fall. On Lake Conway one clutch of eggs was found in January, April, and September, and two clutches were found in March. The mean number of males calling per hour on herp-patrols (Fig. 25) suggest that calling activity was highest from October through May with a lull during the summer. The distribution of individuals recorded each month supports this suggestion: January (N=86), February (82), March (82), April (51), May (29), June (12), July (16), August (6), September (33), October (14), November (54), December (26).

LAKE CONWAY HERPATROL RESULTS FOR EACH MONTH

FIRST THREE YEARS INCLUDED
SPECIES-R.UTRICULARIA

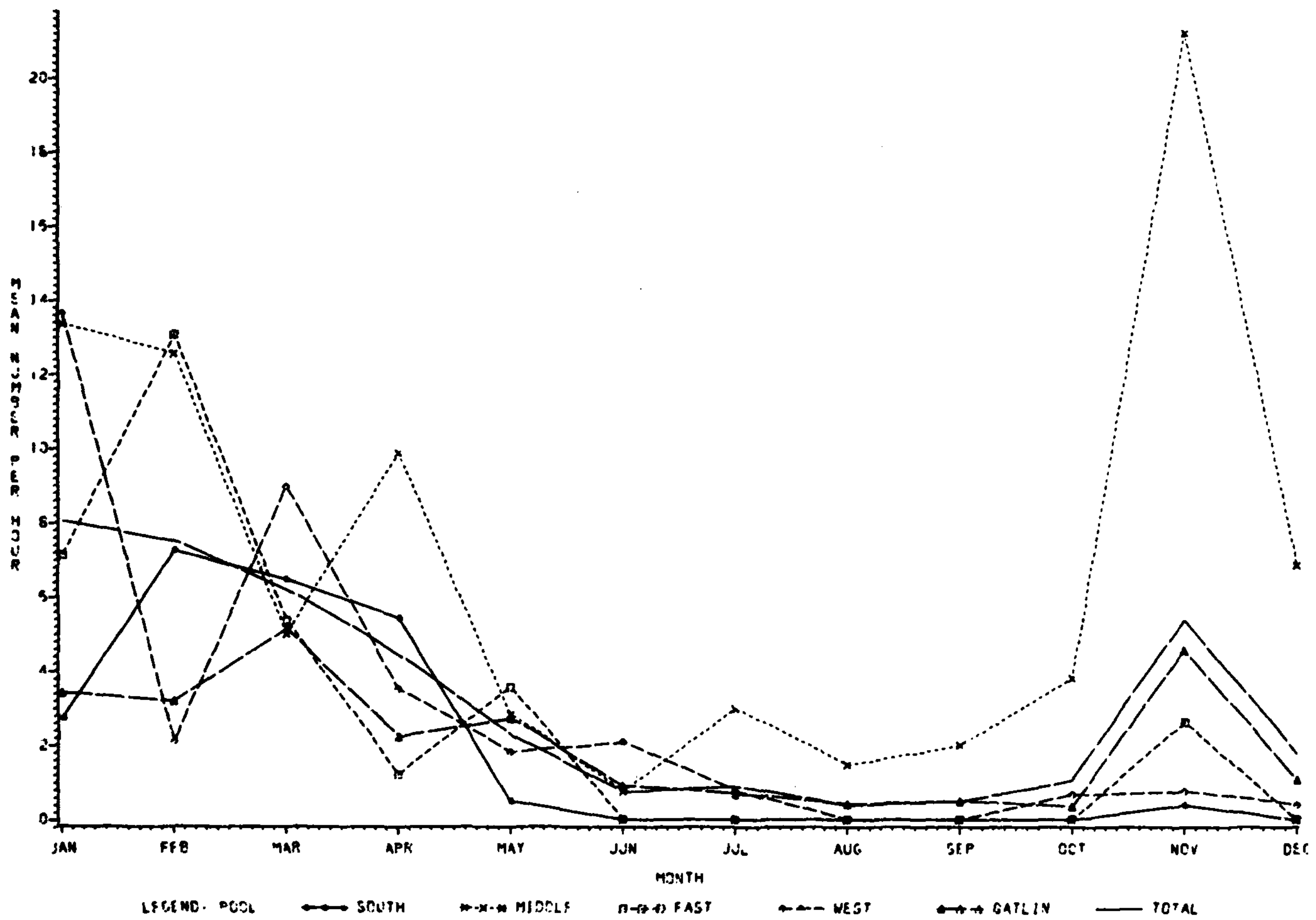

Figure 25. The mean number of Rana utricularia calling per hour in each month on permanent sites during the three-year study.

141. Considerable between-year variation existed in the mean seasonal density of calling males on permanent sites (Fig. 26). For example, the relatively high ($\bar{X}$=17.5/hr.) density of R. utricularia recorded on East Pool during the winter of 1977-78 was not observed in other years. The extraordinary fall and winter peaks on the Middle Pool site (Fig. 26) were largely the result of three trips: the mean recorded density of R. utricularia was 92.07/hr. on 19 November 1979, 47.89/hr. on 4 December 1979, and 55.58/hr. on 10 January 1980. On intervening trips (17 December and 31 January 1980) no R. utricularia were heard. The monthly summaries presented in the previous paragraph also were subject to considerable between-year variation, e.g., 81.8% of the 33 September records were from SY1, 81.5% of the 54 November records were from SY3. The high variance in calling activity of this species was caused chiefly by two factors: weather and social facilitation. Most calling occurred during cold fronts and the calling of one male typically incited others to vocalize. The few instances of calling during the summer months usually were preceded by a late-afternoon shower.

142. In contrast to adult Rana utricularia, tadpoles of this species were most common during the warmer months (Fig. 27). This figure includes tadpoles collected by funnel traps, drift fence, and hyacinth sieve (Table A1), and also provides a summary of the developmental stage of the tadpole if known. The distribution of tadpoles by month in funnel traps was: January (N=5), February (6), March (5), April (10), May (6), June (2), July (9), September (2), December (2). Some individuals also were taken by drift fences (15 in April, 4 in May) and by hyacinth seive (3 in July). The large range of developmental stages in all months with adequate samples suggests either that breeding was nearly continuous or that considerable within-clutch variation in developmental rate existed.

143. The information presented in the previous paragraphs suggests that breeding in Rana utricularia may be nearly continuous but that most reproduction probably occurs between September and May. Although considerable between-year variation in calling activity was recorded, 93.1% occurred during these months. All egg clutches (N=5) also were obtained between September and May.

LAKE CONWAY HERPATROL RESULTS FOR EACH SEASON

FIRST THREE YEARS INCLUDED
SPECIES-R.UTRICULARIA

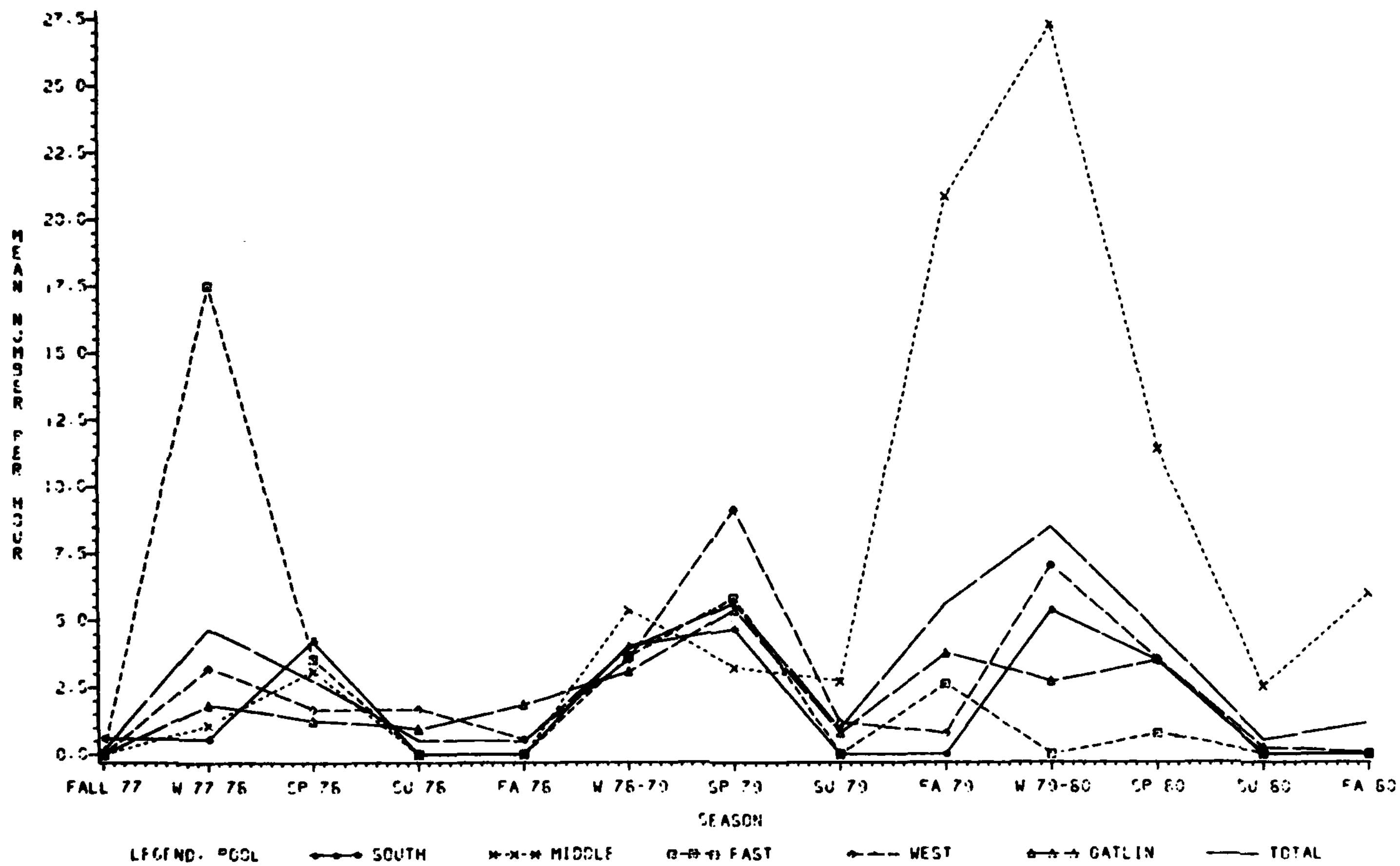

Figure 26. The mean number of <u>Rana</u> <u>utricularia</u> calling per hour in each season on permanent sites during the three-year study.

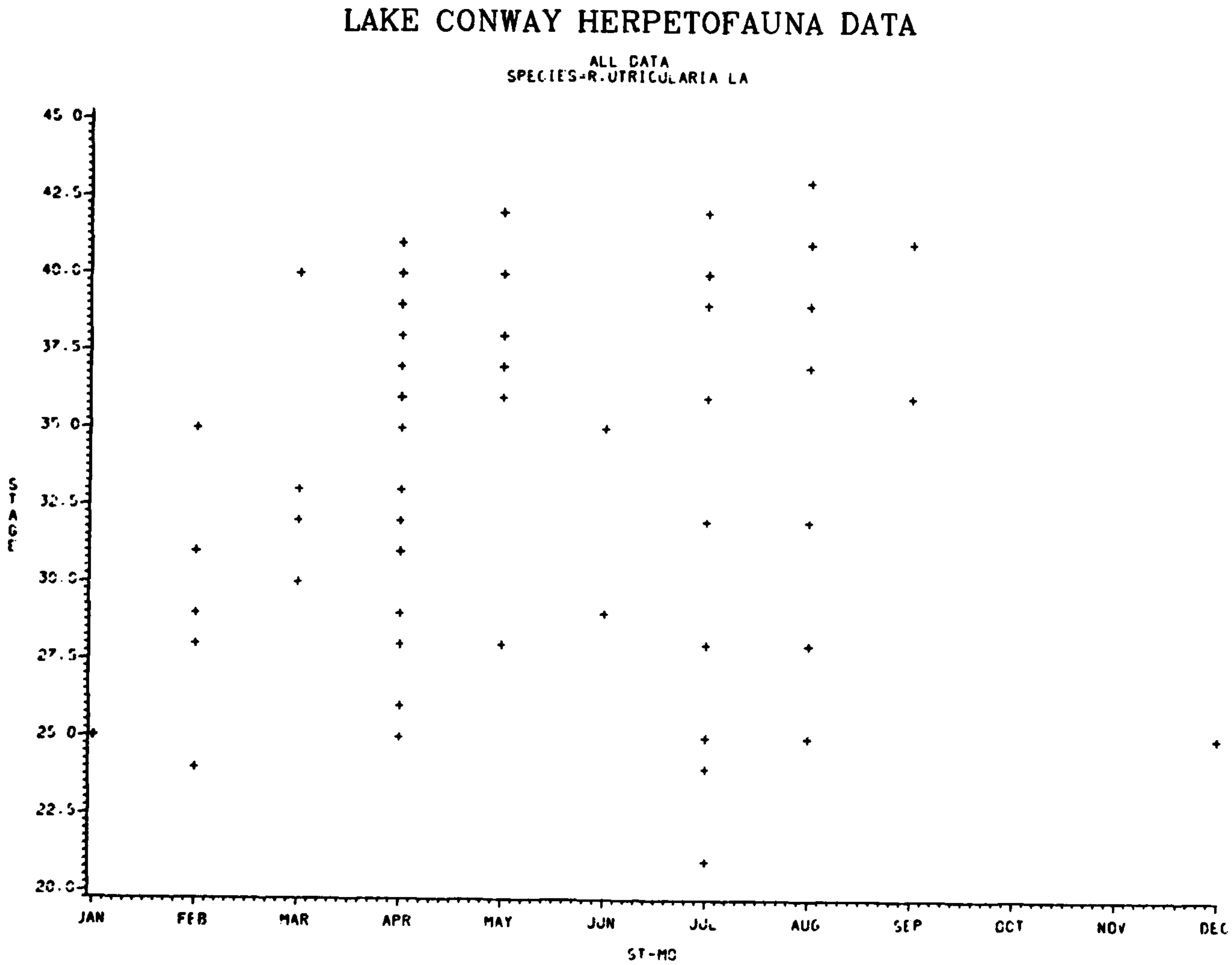

Figure 27. The monthly distribution of Rana utricularia tadpoles staged according to Gosner (1960).

Population Demography

144. Between-site differences in the mean density of calling male *Rana utricularia* were detected during SY3 and for all study years combined (Table A5). Highest densities generally were recorded in Middle Pool, followed by West, East, Gatlin, and South, but considerable between-year variation existed among the sites (Table A5). As mentioned previously, much of this within-site variation in calling was attributable to changes in habitat (paragraph 139) and weather conditions (paragraph 141). Funnel-trapped larvae also showed significant between-site differences in relative density (Table A4). Tadpole densities generally were highest in Middle Pool, followed by East, Gatlin, South, and West. This rank-order was not in accordance with the relative abundance of adults (Table A5, see also discussion in paragraph 135).

145. The only significant change in male *Rana utricularia* calling activity among the study years occurred in Middle Pool (Table A5) with SY1 and SY2 lower than SY3 (χ^2=10.26, P=.0059). The increase in SY3 was attributable to habitat alterations by humans (paragraph 139). Funnel-trapped larvae also showed significant between-year variation in density at the Middle Pool site (χ^2=33.64, P<.0001) and for all pools combined (χ^2=60.14, P<.0001); Middle Pool contributed most to this latter result (Table A5). In both cases larval densities were highest in SY2, intermediate in SY1, and lowest in SY3. The high densities of tadpoles in SY2 (Table A4) may have contributed to the high number of adults in SY3 (Table A5).

Growth and Reproduction

146. Most of the available information on growth and reproduction in *Rana utricularia* on Lake Conway was provided in previous paragraphs. Unlike *Rana grylio* larvae which require at least one year to reach metamorphosis, tadpoles of *R. utricularia* may transform within 67 to 86 days (Wright and Wright 1949:494). Most individuals on Lake Conway probably metamorphose between May and October.

REPTILIA: CROCODILIA

147. The American alligator, the only crocodilian on Lake Conway is an important and conspicuous component of most freshwater habitats in Florida. By

virtue of their size, ecology, and *carnivorous habits*, alligators often are important predators in freshwater environments and contribute considerably to the seasonal dynamics of certain aquatic ecosystems (Kushlan 1974). The Lake Conway population is much below the densities known for similar undeveloped lakes in Florida (see paragraph 157). Thus, the small size of the alligator population makes it highly unlikely that it will have an appreciable effect on the white amur or for that matter on any other species in the system.

Alligator mississippiensis (American alligator)

Distribution and Habitat Preferences

148. American alligators occurred in all pools of the Lake Conway complex (Table A2) but most sightings were from East Pool (N=159), followed by Middle Pool (104), Lake Gatlin (9), South Pool (7), and West Pool (4). Of the total sample of 314 individuals (excluding nests), 38.9% were recorded during alligator censuses; most others were observed during herp-patrols (54.4%) and shoreline censuses (5.7%) (Table A1). Because alligator censuses provided the only systematic means of sampling the population of Alligator mississippiensis on Lake Conway, all analyses are based on this method unless stated otherwise.

149. Figures 28, 29, and 30 show the dispersion of alligators on Lake Conway during the three study years. In all years alligators were most abundant in the marshy area at the north end of Middle Pool (centered at coordinates 305, 425) and throughout much of East Pool which contained the most extensive stretches of undisturbed habitat on Lake Conway. The spotty and inconsistent occurrence of alligators both within and between study years on South, Middle (excluding the marshy area mentioned above), West Pool, and Lake Gatlin suggests that the individuals sighted in these pools may not have been resident animals.

150. On the basis of nocturnal alligator sightings and nesting censuses (Figs. 28-30) and knowledge of the available habitats on Lake Conway it is clear that alligators require stretches of relatively undisturbed shoreline for survival and successful reproduction. White sand beaches and small (<500 m.), isolated patches of littoral zone vegetation did not support alligators on Lake Conway. These habitat requirements probably explain the virtual absence of

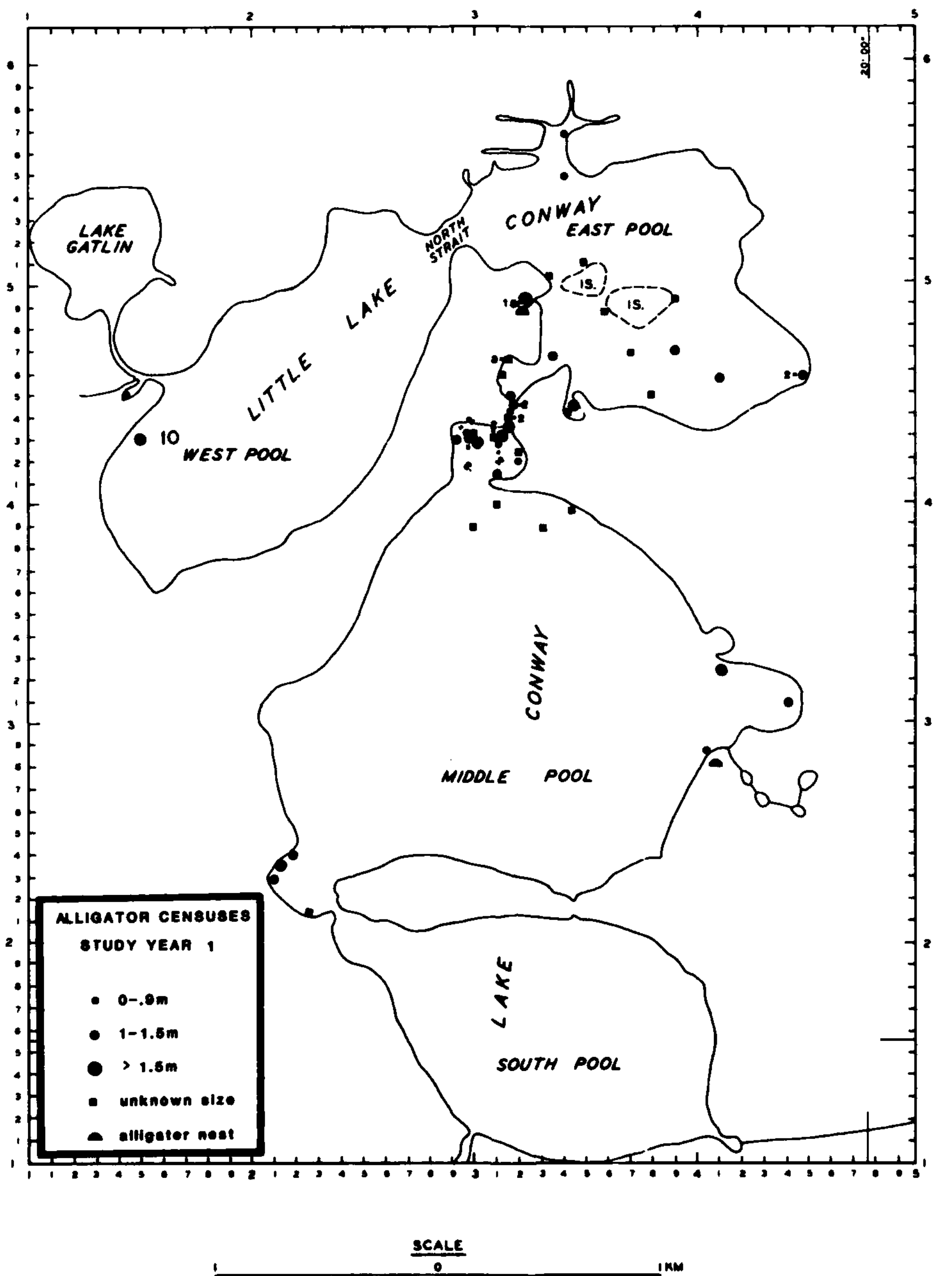

Figure 28. The dispersion of Alligator mississippiensis on Lake Conway during alligator censuses conducted in SY1.

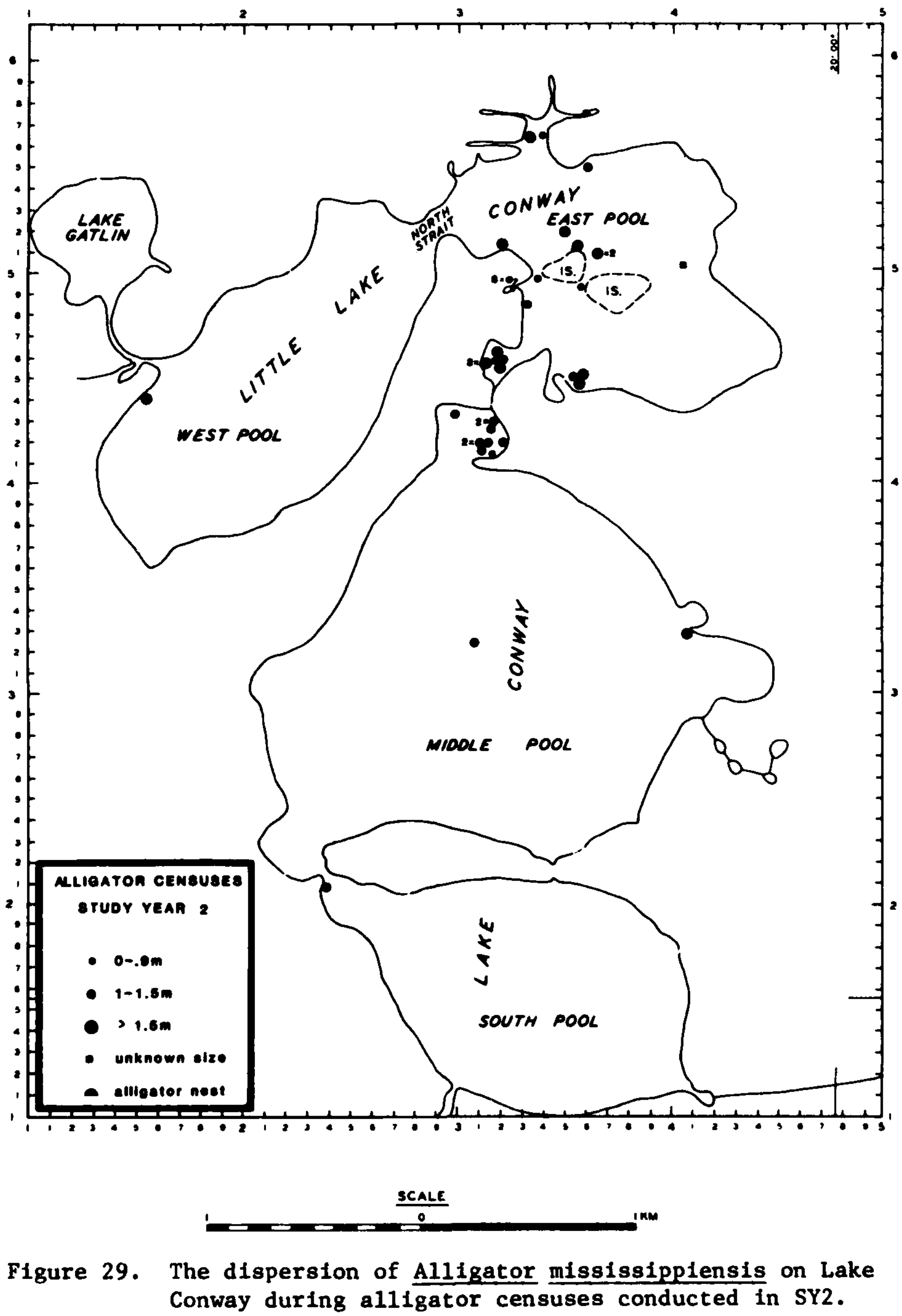

Figure 29. The dispersion of Alligator mississippiensis on Lake Conway during alligator censuses conducted in SY2.

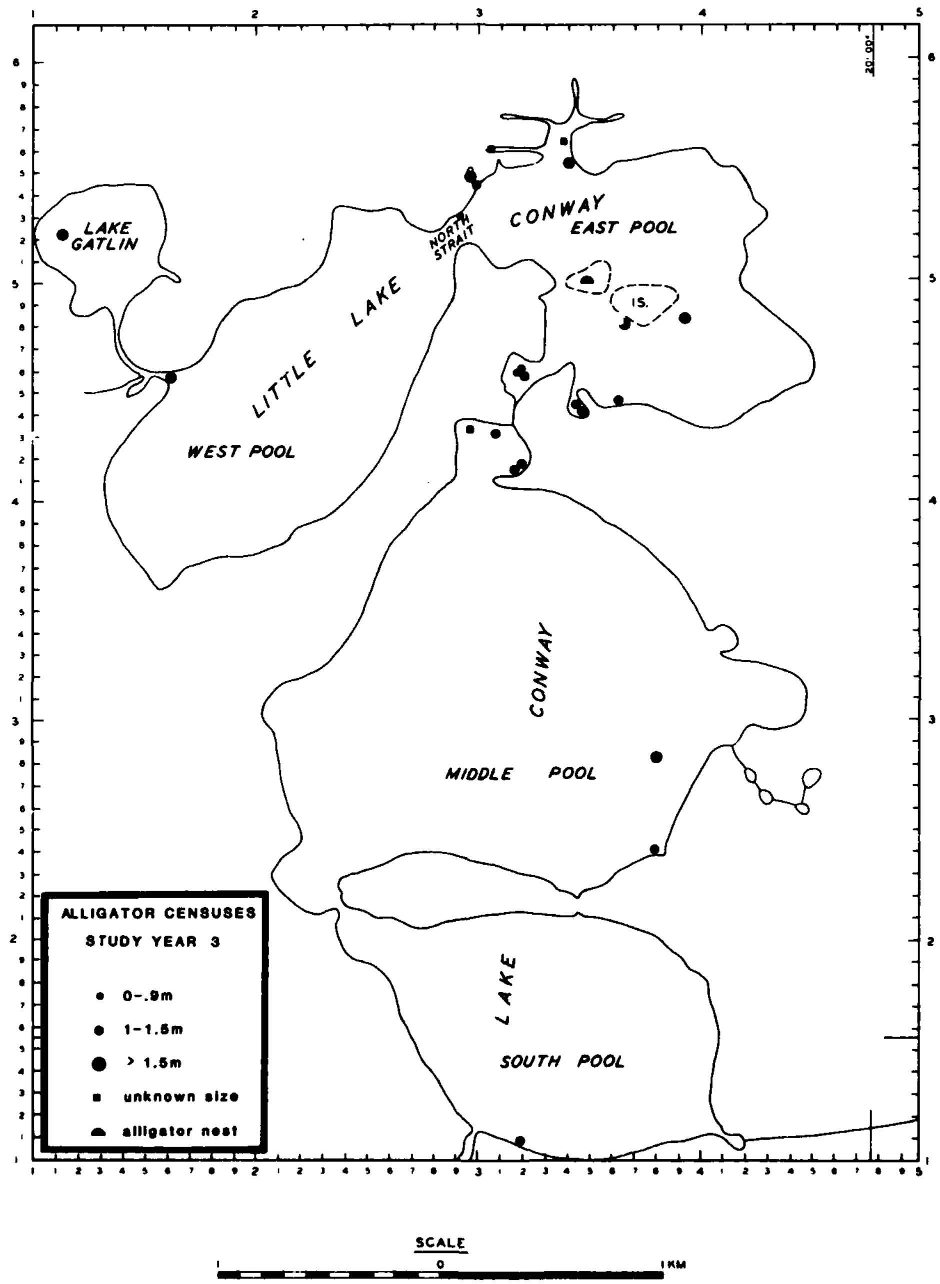

Figure 30. The dispersion of Alligator mississippiensis on Lake Conway during alligator censuses conducted in SY3.

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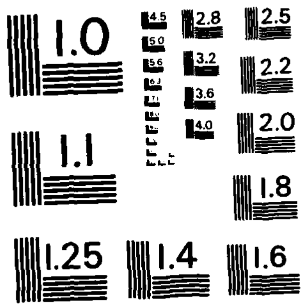

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

alligators on South Pool, much of Middle Pool, West Pool, and Lake Gatlin. A total of four alligator nests were discovered on Lake Conway during the study (Figs. 28-30). One was in a marsh in Middle Pool, one on the East Pool islands, and two near a small pond along the west shore of East Pool. All nesting sites shared a common feature, isolation from human disturbance.

151. Nocturnal census results also suggest a shift in habitat usage with size (and presumed age) of alligators on Lake Conway: 11.8% of 51 alligators $\leq$1.5 m. were spotted farther than 30 m. from shore but 36.8% of alligators >1.5 m. were sighted at a distance of 30 m. or more from shore. Goodwin and Marion (1979) found that habitat preferences of adult alligators in Florida varied with sex and season. Whereas adult males preferred open water habitats in all seasons except winter, adult females used all aquatic habitats in spring and fall but were restricted to the shoreline during the summer nesting season. In winter both sexes spent most time in dens beneath the bank but would bask on sunny days when the air temperature was at least 16°C.

Activity Patterns

152. Figure 31 shows the temporal distribution of alligators seen during the 23 nocturnal censuses of Lake Conway and Figure 32 summarizes these same data by month. Hatchlings concentrated at nest sites would artificially inflate some late summer and early fall samples and, therefore, were excluded from the figures. Alligators were active at night in every month except January and February. Apparent peaks in nocturnal activity occurred in spring and in late summer-early fall. The high variance between sampling trips probably was related to weather conditions on the night of sampling (Woodward and Marion 1978).

153. The latest and earliest recorded dates of aquatic nocturnal activity for alligators on Lake Conway were 16 December 1978 and 14 March 1979. However, some diurnal basking activity was observed on warm days during the months of January and February in most years. These data suggest that Lake Conway alligators probably actively foraged at night from late March through November when water temperatures were above 20° C. During the cooler months activity was limited to occassional basking when weather conditions were favorable.

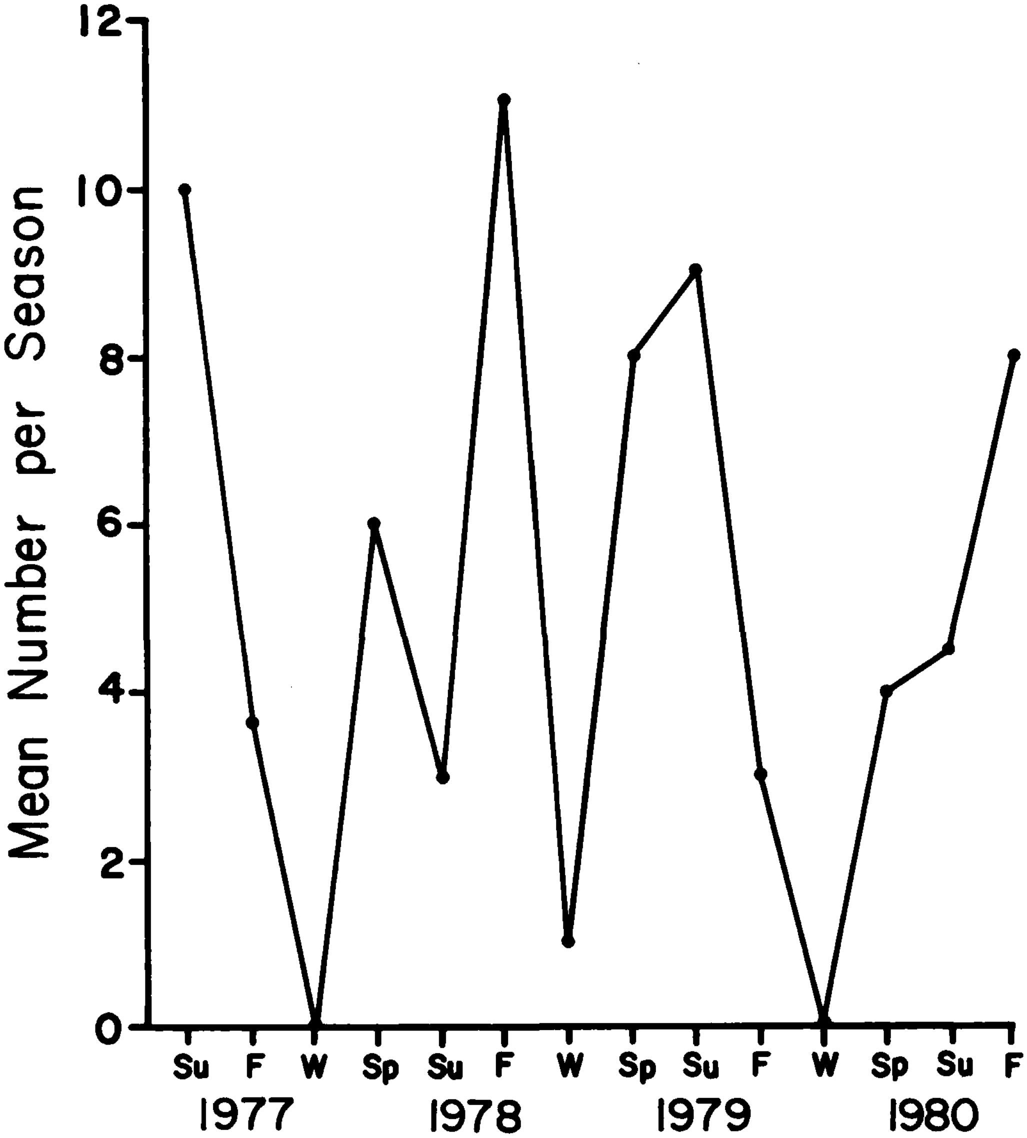

Figure 31. The mean number per season of Alligator mississippiensis seen on nocturnal censuses of Lake Conway.

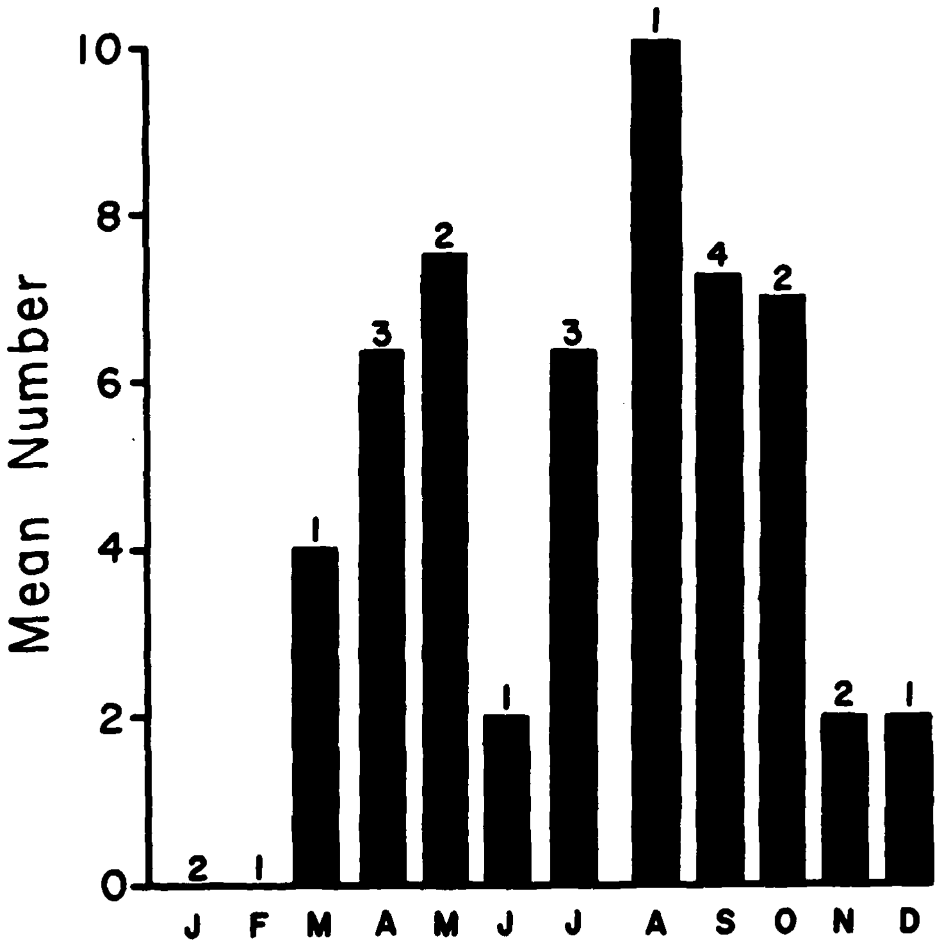

Figure 32. The mean number of Alligator mississippiensis seen each month on nocturnal censuses of Lake Conway. Numbers represent the number of censuses conducted each month.

Population Demography

154. Total length could be estimated for 91 of the 116 individuals (excluding 27 hatchlings) observed on nocturnal alligator censuses during the study (Fig. 33); the remainder (N=25) submerged before their size could be estimated. No significant between-pool differences in the mean total length of alligators were detected (Kruskal-Wallis test, P=.88), although individuals from East Pool averaged larger ($\bar{X}$=1.40 m., N=48) than those from Middle Pool ($\bar{X}$=1.25 m., N=34). The Conway sample was dominated by immature individuals (< 1.5 m.) with less than 34% greater than 1.6 m., the minimum size of adults (McIlhenny 1935). Large alligators (>3.0 m.) were conspicuously absent.

155. Table 12 summarizes yearly trends in the relative density of alligators on Lake Conway by pool. To facilitate a comparison of these results with Florida Game and Fresh Water Fish Commission's (FGFWFC) nocturnal census data for other Florida lakes (Hines 1976), relative densities also are expressed as the mean number of alligators per kilometer of shoreline during the major activity season (April-September).

156. Our census results indicate that alligator densities averaged 5 to 6 times greater in Middle and East Pools than in the other pools. This relationship did not vary substantially between years. The absence of alligators during censuses in some pools in some years probably reflected their low abundance, but not their extirpation in that year.

157. Mean relative alligator densities during their active season for the total Conway system were similar in SY1 (0.21/km.) and SY2 (0.21/km.), but somewhat lower in SY3 (0.15/km.). Because these densities were very low (see below) it was difficult to evaluate yearly trends in alligator populations on the lake. Data available from FGFWFC (Hines 1976) suggested that the alligator population on Lake Conway was much smaller than that of most other Florida lakes. Nocturnal surveys conducted by FGFWFC in seven Florida counties during 1974-75 yielded a mean of 7.02 alligators per kilometer of shoreline for lake habitats (range=0.44-33.01/km.). This mean relative density estimate is 36.9 times greater than that for Lake Conway ($\bar{X}$=0.19/km.) during the same season (Table 12). Unfortunately the extent of urbanization on the lakes censused by FGFWFC was not documented. Elsewhere Hines (1979:230) noted that Lake Griffin, Lake County Florida, which "....has a dense human population around a large

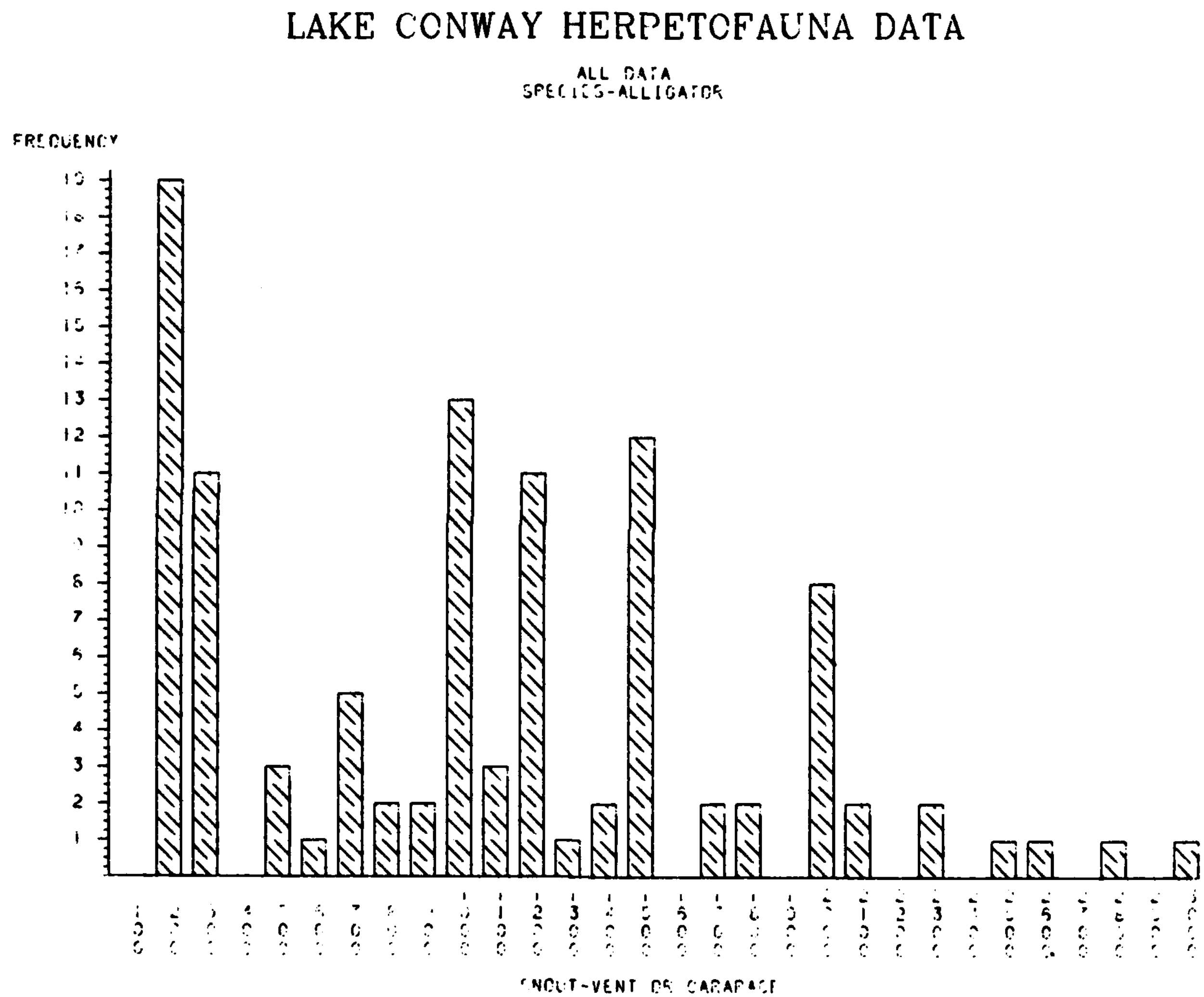

Figure 33. The size frequency distribution of <u>Alligator</u> <u>mississippiensis</u> seen on nocturnal censuses of Lake Conway.

Table 12

The mean number of American alligators seen during nocturnal censuses of Lake Conway by pool and study year. Raw values represent census results for the total year, values in parentheses represent only censuses conducted from April through September. The number of censuses was 10(6) in SY1, 7(4) in SY2 and 6(4) in SY3.

	South Pool	Middle Pool	East Pool	West Pool	Lake Gatlin	Conway Total
Study Year 1						
per census	0.00(0.00)	2.50(3.17)	2.70(3.83)	0.10(0.17)	0.10(0.17)	5.40(7.33)
per km. shoreline	0.00(0.00)	0.23(0.30)	0.28(0.39)	0.02(0.03)	0.03(0.05)	0.16(0.21)
Study Year 2						
per census	0.28(0.50)	1.57(2.00)	3.71(4.50)	0.28(0.25)	0.00(0.00)	5.85(7.25)
per km. shoreline	0.05(0.09)	0.15(0.19)	0.38(0.46)	0.05(0.05)	0.00(0.00)	0.17(0.21)
Study Year 3						
per census	0.17(0.25)	1.00(1.50)	2.33(3.00)	0.00(0.00)	0.33(0.50)	3.83(5.25)
per km. shoreline	0.03(0.04)	0.09(0.14)	0.24(0.31)	0.00(0.00)	0.10(0.15)	0.11(0.15)
Total Study						
per census	0.13(0.21)	1.83(2.36)	2.91(3.79)	0.13(0.14)	0.13(0.21)	5.13(6.71)
per km. shoreline	0.02(0.04)	0.17(0.21)	0.30(0.39)	0.02(0.03)	0.04(0.06)	0.15(0.19)

portion of the shoreline", had a mean alligator density of 43.4 per km. of shoreline.

158. Five lines of evidence indicate that the alligator population on Lake Conway probably is declining in size: (1) Littoral zone habitat, which is necessary for survival and successful reproduction of alligators, has declined continually on Lake Conway (Williams et al. 1982). (2) Figure 32 suggests that alligators have declined during the study. The mean number sighted per trip was 5.40 in SY1, 5.85 in SY2, and 3.87 in SY3. (3) In SY1 two females nested successfully (see paragraph 161), in SY2 one female, and to our knowledge none was successful in SY3. (4) Although not statistically significant ($P > .23$, Kruskal-Wallis test) the mean recorded size of censused individuals increased from 1.23 m. in SY1, to 1.37 m. in SY2, to 1.46 m. in SY3, suggesting lower recruitment. (5) The nuisance alligator program of the Florida Game and Fresh Water Fish Commission removed at least three of the adult alligators from Lake Conway during the study (one individual from Middle and East Pools and one from Lake Gatlin) and at least two other adult alligators were reported killed by local residents. Because the maximum number of adult alligators seen on any census was three, these removals probably represented a substantial proportion of the breeding population.

Food Habits

159. On Lake Conway no alligators were taken for stomach analysis. Fogarty and Albury (1967) summarized what is known of the diet of alligators in Florida. Immature individuals primarily eat invertebrates but adults feed extensively on vertebrates, especially fish and smaller turtles. This suggests that the low abundance of alligators on Lake Conway may have relieved a major, natural predatory pressure for turtles on the lake system.

Growth and Reproduction

160. Because alligators were not marked, growth information is unavailable for the Lake Conway population. In general, growth rates of *A. mississippiensis* average about 0.3 m. per year until maturity (at age 5 for females, age 9 for males) when growth slows (McIlhenny 1935, Chabreck and Joanen 1979).

161. Four alligator nests were discovered on Lake Conway during the study. Two nests were found in the summer of 1977; one behind the Middle Pool

permanent site (coordinates 410, 280); the other along the south shore of a small pond on the west side of East Pool (323, 494). Both nests successfully hatched 12-16 young. In April 1978 the nest site in Middle Pool was bull-dozed for a housing development (Godley et al. 1981:26) and to our knowledge no alligator nested in Middle Pool for the remainder of the study. In the summer of 1978 a nest was located on the north shore of the pond on the western side of East Pool (325, 497). This nest, possibly constructed by the same female from the previous year, produced at least 18 young. The following spring FGFWFC killed a large "nuisance" alligator from this pond and no nesting occurred at this site in that year. No other nests were located on the lake in 1979. In 1980 one alligator nest was found on the East Pool islands (351, 510). However, river otters (Lutra canadensis) apparently destroyed the 8-10 eggs present.

REPTILIA: TESTUDINATA

162. The chelonian fauna of Lake Conway consists of ten species representing four families. The largest family present is the Emydidae with five species and three genera: Deirochelys reticularia, Pseudemys floridana, P. nelsoni, P. scripta and Chrysemys picta; the latter two are introduced species on the lake system. The Kinosternidae is represented by three species (Kinosternon baurii, K. subrubrum, Sternotherus odoratus), and two families by single species: Chelydridae (Chelydra serpentina) and Trionychidae (Trionyx ferox).

163. Functionally, turtles probably are the most important herpetofaunal taxa on Lake Conway. In numerical abundance turtles comprised 40.51% of the total herpetofaunal observations (Table A1) and were second only to anurans (49.33%). The biomass contribution of turtles is staggering. In the three-year study we processed 1,310.8 kg. of turtles on the lake system. Because only about 15% of these individuals were ever recaptured and because we only censused about one fourth of the shoreline, the total standing crop of turtles on Lake Conway probably exceeds 11 metric tons (14.97 kg. per ha.). Considering that turtles primarily are restricted to the vegetated regions of the lake system less than 3 m. in depth, the ecological standing crop of

turtles on Lake Conway probably approaches 225.0 kilograms per hectare.

Chelydra serpentina (Florida snapping turtle)

Distribution and Habitat Preferences

164. A total of 21 snapping turtles (including six recaptures) was collected on Lake Conway with one individual from South Pool, five from East Pool, eight from West Pool, and five from Gatlin Canal (Table A2). None was observed in Middle Pool but the species probably occurred there. Most specimens were collected along the permanent sites in the littoral zone either by funnel traps (N=12), herp-patrols (N=8), or shoreline censuses (N=1) (Table A1).

165. Preferred habitat appeared to be shallow (<1 m.) water with an abundance of aquatic vegetation and a mud substratum. In order of decreasing abundance the dominant vegetation where C. serpentina was collected was Eichhornia crassipes (N=6), Panicum hemitomon (5), P. repens (4), Vallisneria americana (2) and Typha latifolia (1). No individuals were observed on beach habitats, but five were recorded from bare areas near vegetation. Perhaps because the species was relatively uncommon, no significant changes in distribution or habitat preference were detected since the white amur introduction.

Activity Patterns

166. On Lake Conway, snapping turtles apparently were active year-round. All months except July and September were represented in the 25 total captures with no apparent seasonal trends. All individuals seen at night were active.

Population Demography

167. Figure 34 shows the size frequency distribution of C. serpentina collected on Lake Conway. Juveniles were well-represented in the sample; most of these were collected in funnel traps. Excluding recaptures, adult males outnumbered adult females 4 to 1, possibly because males were more active. The high proportion of recaptured individuals (6 of 19 marked) suggests that the population of C. serpentina on Lake Conway was rather small. Because the species seems restricted to the littoral zone and because of the rapid urbanization of Lake Conway, the population probably is declining.

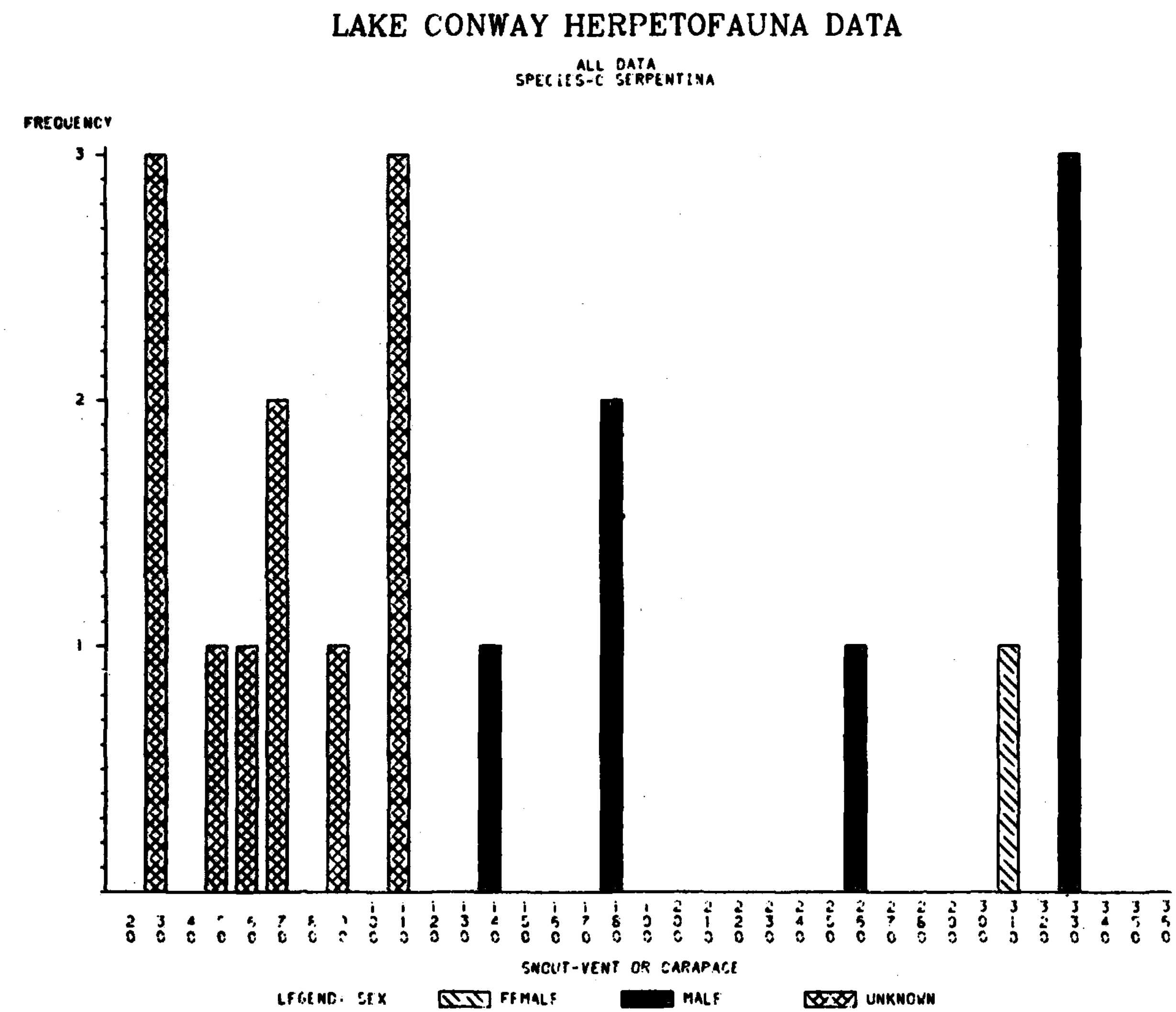

Figure 34. The size frequency distribution of *Chelydra serpentina* from Lake Conway.

Food Habits

168. Only one snapping turtle, a 712 g. juvenile male which accidentally drowned in a funnel trap, was collected for gut analysis. It contained 42.37 g. of fish (Notemigonus crysoleucas and Lepomis spp.). Most live snappers collected in funnel traps had eaten all or part of the cut-fish bait. These findings indicate that snappers are attracted to carion, an observation which had been reported previously (Lagler 1943, Alexander 1943, Ernst and Barbour 1972). In West Pool an adult female, which was too large to enter the funnel trap, was found with its nose facing the baited corner of the trap. Punzo (1975) summarized dietary information for Florida C. serpentina and reported that the species is omnivorous, feeding on a variety of aquatic plants, flatworms, annelids, arthropods, snails, and vertebrates.

Reproduction and Growth

169. No information concerning reproduction of Lake Conway C. serpentina was gathered. Other studies (Ernst and Barbour 1972, Punzo 1975) have shown that adult female C. serpentina deposit several clutches of 6 to 83 eggs in late [illegible]ing to early summer of each year. The young emerge from the nest the same year.

170. Growth of C. serpentina on Lake Conway apparently was rapid. One recaptured juvenile grew from 108 mm. to 140 mm. CL in nine months ($\bar{X}$=3.6 mm./month). A young adult male (197 mm. CL) grew 2 mm. and gained 70 g. in two months. An adult radiotelemetried male (327 mm. CL) with 11 distinct growth rings grew only 1 mm. CL in 1.25 years. Florida snapping turtles apparently mature in about six years at a CL of 200 mm. (Ernst and Barbour 1972).

Chrysemys picta (Painted turtle)

171. Only one specimen of the introduced painted turtle was collected on Lake Conway in East Pool during the fourth study year. This young individual (121 mm. CL) was most clearly referable to the subspecies C. p. belli which normally occurs west of the Mississippi River and north of Arkansas (Conant 1975). Because only one C. picta was collected during the study and because the species does not range as far south as Florida, a breeding population of C. picta probably is not established on Lake Conway. The one collected individual

defecated gastropod (Viviparous sp.) shells and opercula. This specimen was removed from the lake system.

Deirochelys reticularia (Chicken turtle)

172. Only two chicken turtles were observed during the entire study (Table A3). Both (a male and a female) were collected in February in Gatlin Canal; the male was recaptured 2 weeks later 30 m. from the release site. Presumably the species occurs in other pools but extensive collecting has failed to reveal its presence.

173. Zug and Schwartz (1971) reviewed the biology of chicken turtles, and Gibbons and Greene (1978) discussed the demography and ecology of a South Carolina population. The species is most common in quiet, shallow bodies of water with an abundance of aquatic vegetation. The diet consists chiefly of aquatic invertebrates (especially crayfish) but some plant material is taken (Ernst and Barbour 1972). In a South Carolina population, males mature at age two or three but females mature at six to eight years; clutches of 2-12 eggs are deposited in spring and fall (Gibbons 1969, Gibbons and Greene 1978, Gibbons et al. 1978).

Pseudemys floridana (Peninsular cooter)

Distribution and Habitat Preferences

174. Peninsular cooters were the second most abundant turtle species on Lake Conway, accounting for 18.67% of the total turtle sightings and 7.56% of the total herpetofaunal observations (Table A2). Most (90.90%) Pseudemys floridana were taken on herp-patrols (Table A1). The distribution of total sightings by pool was 470 from South, 161 from East, 136 from Middle, 109 from Gatlin, and 25 from West (Table A2). Only 35.36% of the 901 records for this species were from permanent sites (Tables A2, A3). In addition, the percent contribution of the permanent sites to these pools totals varied: South = 22.77%, Middle = 26.47%, East = 41.61%, West = 32.00%, Gatlin = 94.50%. Importantly, the relative contribution of each pool and permanent site to the species' total changed during the study (Tables A2, A3). For example, South

Pool accounted for 44.4% and 43.9% of the P. floridana records in SY1 and SY2, but 63.4% of the SY3 observations (Table A2); on the permanent sites the contribution of South Pool decreased from 47.9% in SY1 to 18.0% in SY2 to 6.5% in SY3. This variation among study years requires careful interpretation of temporal changes in habitat use.

175. Table 13 summarizes for all pools yearly changes in the relative abundance of Pseudemys floridana on herp-patrols by the five major habitat categories. All habitats show temporal shifts in usage (χ^2=133.71, P<.0001). The relative importance of the littoral zone category, which includes sightings in habitats dominated by Eichhornia crassipes, Fuirena scirpoides, Nymphaea odorata, Nuphar luteum, Panicum hemitomon, P. repens, Pontederia lanceolata and Typha latifolia, decreased during the study from 64.1% of all records in SY1 to 54.8% in SY2 to 36.3% in SY3. This shift probably was caused by two factors: (1) continual conversion of the littoral zone to beach habitat on Lake Conway, and (2) concomitant yearly increases in the mean size of P. floridana on the lake system (see paragraphs 191-196). Although the proportion of herp-patrol observations in the littoral zone decreased during the study, no temporal changes were detected in the relative importance of particular species of emergent plants.

176. Changes in usage patterns of open water habitats by peninsular cooters reflect shifts in macrophyte communities as a result of white amur feeding activity. Using the macrophyte availability information provided in Schardt et al. (1981: Fig. J6-J10) and the utilization patterns of these plant species by P. floridana given in Table 13, the following lake-wide trends emerge: (1) a 73.8% reduction in Potamogeton illinoensis coverage from SY1 to SY3 was matched by a 61.4% decrease in cooter sightings in this habitat, (2) as the percent coverage of Vallisneria americana and Nitella megacarpa increased 73.5% and 35.7%, respectively from SY1 to SY3, dramatic increases in the use of habitats dominated by these plant species by P. floridana were recorded, and (3) as the amount of lake bottom devoid of macrophytes increased from 328 ha. in SY1 to 416 ha. in SY3, the number of cooters seen over bare bottom increased from none in SY1 to 18 in SY2 and to 38 in SY3.

177. On Lake Conway both macrophyte community structure and the relative proportion of Pseudemys floridana observed varied by pool and by study year.

Table 13

Habitat analysis of the yearly distribution of *Pseudemys floridana* on Lake Conway.

	Nitella megacarpa	*Potamogeton illinoensis*	*Vallisneria americana*	Bare bottom	Littoral zone	Total (%)
Study Year 1						
Observed	0	40	2	0	75	117
Expected	12.2	24.8	13.7	11.6	54.5	(21.04)
Chi-square	12.2	9.3	10.0	11.6	7.7	
Study Year 2						
Observed	0	38	6	18	74	136
Expected	14.2	28.9	15.9	13.5	63.4	(24.46)
Chi-square	14.2	2.9	6.2	0.9	1.8	
Study Year 3						
Observed	58	40	57	38	110	303
Expected	31.6	64.3	35.4	30.0	141.1	(54.50)
Chi-square	22.0	9.2	13.1	2.1	6.9	
Total (%)	58 (10.43)	118 (21.22)	65 (11.69)	56 (9.89)	259 (46.58)	556 (100.00)

As a result the lake-wide analysis of habitat usage reported above may mask important trends within each pool. To reduce this possible bias, habitat availability-usage patterns were compared within each pool using the same data sets mentioned above. The distribution of individuals with habitat information by pool was 315 in South, 79 in Middle, 89 in East, 18 in West, and 55 in Gatlin. The three pools with the largest samples showed significant yearly differences in habitat use by P. floridana. All were in the expected direction based on changes in macrophyte populations reported by Schardt et al. (1981: Fig. J6-J10).

178. In many ways the effects on *P. floridana* of alterations in macrophyte populations by white amur feeding activity were best exemplified by South Pool (Table 14). This pool had the highest densities of *P. floridana* on the lake system (Table A5) and the turtle showed highly significant (X^2=91.08) shifts in habitat use (Table 14) as well as other life history traits through the study (see below). Without belaboring the point, as *Potamogeton illinoensis* decreased in abundance, *P. floridana* shifted to other, more abundant plant species (e.g., *Nitella megacarpa*, *Vallisneria americana*) or spent more time over bare bottom.

179. Significant yearly changes in habitat use by peninsular cooters also were obtained in Middle (X^2=12.83, P<.05) and East Pools (X^2=18.49, P=.005). The significant result in Middle Pool was largely the result of bare bottom: fewer observations than expected were obtained in SY1 (when the habitat was rarer) and more than expected in post-stocking years. In East Pool shifts in the relative and absolute abundances of *Potamogeton illinoensis* and *Vallisneria americana* were responsible for the significant chi-square value.

180. The large size of the *Pseudemys floridana* sample with habitat information (N=465) permitted an analysis of size and sexual differences. In this species, sexual size dimorphism is great (see Population Demography section) with adult females weighing over 600 times as much as the hatchlings they produce. Thus, yearly changes in macrophyte population density could affect differentially these size-sex categories. To test this possibility habitat selection in males, females and juveniles was examined on a pool-wide basis. The patterns for juveniles ($\bar{X}$ CL=75.4 mm.), males ($\bar{X}$ CL=160.7 mm.), and females ($\bar{X}$ CL=264.1 mm.) were distinct from one another and each showed

Table 14

Habitat analysis of the yearly distribution of *Pseudemys floridana* in South Pool.

	Nitella megacarpa	*Potamogeton illinoensis*	*Vallisneria americana*	Bare bottom	Littoral zone	Total (%)
Study Year 1						
Observed	0	27	0	0	28	55
Expected	10.1	15.7	3.3	6.6	19.2	(17.46)
Chi-Square	10.1	8.1	3.3	6.6	4.0	
Study Year 2						
Observed	0	32	1	7	30	70
Expected	12.9	20.0	4.2	8.4	24.4	(22.22)
Chi-square	12.9	7.2	2.5	0.2	1.3	
Study Year 3						
Observed	58	31	18	31	52	190
Expected	35.0	54.3	11.5	22.9	66.2	(60.32)
Chi-square	15.1	10.0	3.7	2.8	3.1	
Total (%)	58 (18.41)	90 (28.57)	19 (6.03)	38 (12.06)	110 (34.92)	315 (100.00)

significant yearly shifts in habitat use (Tables 15-17). First we compared intraspecific trends, then yearly trends within each size-sex category.

181. The most obvious size trend was the greater dependence of juvenile P. floridana on littoral zone vegetation, i.e., 63.87% of the juveniles were observed in the littoral zone but only 40.00% of the males and 28.24% of the females. This phenomenon appears to be correlated with size in that juveniles and smaller males and females were encountered more often in the littoral zone than their larger counterparts. The shift to open water habitats with increasing body size also was obvious within the submerged macrophyte categories, i.e., a greater preponderance of juveniles and males were sighted in shallows dominated by Potamogeton illinoensis and Vallisneria americana, whereas a higher percentage (25.53% of open water sightings) of adult females were over Nitella megacarpa, which typically grew at greater depths (Schardt et al. 1981). The proportion of individuals seen over bare substratum also increased with size. These intraspecific differences appear most related to diet and protection from predators, although improved locomotor efficiency with increasing body size may have made deeper, open water environments more available to larger animals.

182. Within each of the size-sex classes, yearly shifts in habitat use were pronounced (Tables 15-17) and all showed significant effects (juvenile X^2=18.87, P=.016; male X^2=52.98, P<.0001; female X^2=47.25, P<.0001). In most instances the trends followed those established previously for the species (Table 13) but important intraspecific differences existed. Among juveniles the dependence on the littoral zone did not change with study year even though this habitat decreased in abundance on the lake system; accordingly the littoral zone category contributed least to chi-square. Potamogeton illinoensis was the preferred open water plant species of juveniles and reductions in its availability resulted in shifts to other macrophytes. We suspect that P. illinoensis was an important habitat for invertebrate prey taken by some small peninsular cooters (see Food Habits section). Yearly changes among males and females were of similar direction but of a different magnitude. After SY1, females showed a more pronounced shift away from the littoral zone than males, and a higher percentage of females than males was observed over Vallisneria americana and Nitella megacarpa in the later study

Table 15

Habitat analysis of the yearly distribution of juvenile *Pseudemys floridana* on Lake Conway.

	Nitella megacarpa	*Potamogeton illinoensis*	*Vallisneria americana*	Bare bottom	Littoral zone	Total (%)
Study Year 1						
Observed	0	12	0	0	26	38
Expected	1.6	7.7	2.2	2.2	24.3	(31.93)
Chi-square	1.6	2.5	2.2	2.2	0.1	
Study Year 2						
Observed	0	6	1	2	16	25
Expected	1.1	5.0	1.5	1.5	16.0	(21.01)
Chi-square	1.1	0.2	0.2	0.2	0.0	
Study Year 3						
Observed	5	6	6	5	34	56
Expected	2.4	11.3	3.3	3.3	35.8	(47.06)
Chi-square	3.0	2.5	2.2	0.9	0.1	
Total	5	24	7	7	76	119
(%)	(4.20)	(20.17)	(5.88)	(5.88)	(63.87)	(100.00)

Table 16

Habitat analysis of the yearly distribution of male *Pseudemys floridana* on Lake Conway.

	Nitella megacarpa	*Potamogeton illinoensis*	*Vallisneria americana*	Bare bottom	Littoral zone	Total (%)
Study Year 1						
Observed	0	12	1	0	21	34
Expected	4.4	7.9	4.3	3.8	13.6	(15.81)
Chi-square	4.4	2.1	2.5	3.8	4.0	
Study Year 2						
Observed	0	17	1	11	25	54
Expected	7.0	12.6	6.8	6.0	21.6	(25.12)
Chi-square	7.0	1.6	4.9	4.1	0.5	
Study Year 3						
Observed	28	21	25	13	40	127
Expected	16.5	29.5	15.9	14.2	50.8	(59.07)
Chi-square	7.9	2.5	5.1	0.1	2.3	
Total (%)	28 (13.02)	50 (23.26)	27 (12.56)	24 (11.16)	86 (40.00)	215 (100.00)

Table 17

Habitat analysis of the yearly distribution of female *Pseudemys floridana* on Lake Conway.

	Nitella megacarpa	*Potamogeton illinoensis*	*Vallisneria americana*	Bare bottom	Littoral zone	Total (%)
Study Year 1						
Observed	0	2	1	0	12	15
Expected	2.7	2.6	3.3	2.1	4.2	(11.45)
Chi-square	2.7	0.2	1.6	2.1	14.2	
Study Year 2						
Observed	0	10	3	1	8	22
Expected	4.0	3.9	4.9	3.0	6.2	(16.79)
Chi-square	4.0	9.8	0.7	1.4	0.5	
Study Year 3						
Observed	24	11	25	17	17	94
Expected	17.2	16.5	20.8	12.9	26.5	(71.76)
Chi-square	2.7	1.8	0.8	1.3	3.4	
Total (%)	24 (18.32)	23 (17.56)	29 (22.14)	18 (13.74)	37 (28.24)	131 (100.00)

years.

183. To summarize, on Lake Conway Pseudemys floridana showed pronounced shifts in habitat use during the study. Both loss of the littoral zone through habitat destruction and alteration of submerged macrophyte communities through preferential grazing by white amur were implicated as the major causes. The magnitude but not the direction of change in habitat use varied intraspecifically and among pools. The differences in habitat selection among pools were correlated with and presumably caused by changes in habitat quality specific to the particular pool.

Activity Patterns

184. Only two peninsular cooters were collected in funnel traps, and little is known of their diel activity cycles. The species was observed feeding in the day and night, and telemetry observations (presented elsewhere) indicated that movement occurred throughout the daily cycle. Some radiotelemetried adults of both sexes made regular nocturnal visits to the littoral zone and returned to specific open water habitats during the day; other individuals rarely frequented the littoral zone.

185. Here, we examine monthly and yearly seasonal trends in activity based on the number of Pseudemys floridana observed per hour on herp-patrols of the permanent sites. Clearly, these data reflect only nocturnal activity in the shallows and along the edge of the littoral zone (see paragraph 14 for methods and rationale); diurnal patterns in the same habitat or diel patterns in deep-water habitats may be different. Mean monthly trends in nocturnal activity on the permanent sites (Fig. 35) indicate that on Lake Conway some individuals of P. floridana are active in the water year-round. The mean for all pools and months combined was 0.71 P. floridana/hr. (2SE=0.147/hr.). The monthly means for all pools combined ranged from 0.454/hr in August to 1.344/hr in December. The variance between trips within a month was high, with 2 SE's about the mean ranging from 0.317/hr in March to 0.764/hr in December. This variation includes that attributable to weather conditions, pool and year effects.

186. Some pools showed distinct monthly trends in P. floridana activity. For example, in South Pool activity levels were highest during the summer months (Fig. 36), a consistent trend among study years (Fig. 37). Juveniles

LAKE CONWAY HERPATROL RESULTS FOR EACH MONTH

FIRST THREE YEARS INCLUDED
SPECIES-P.FLORIDANA

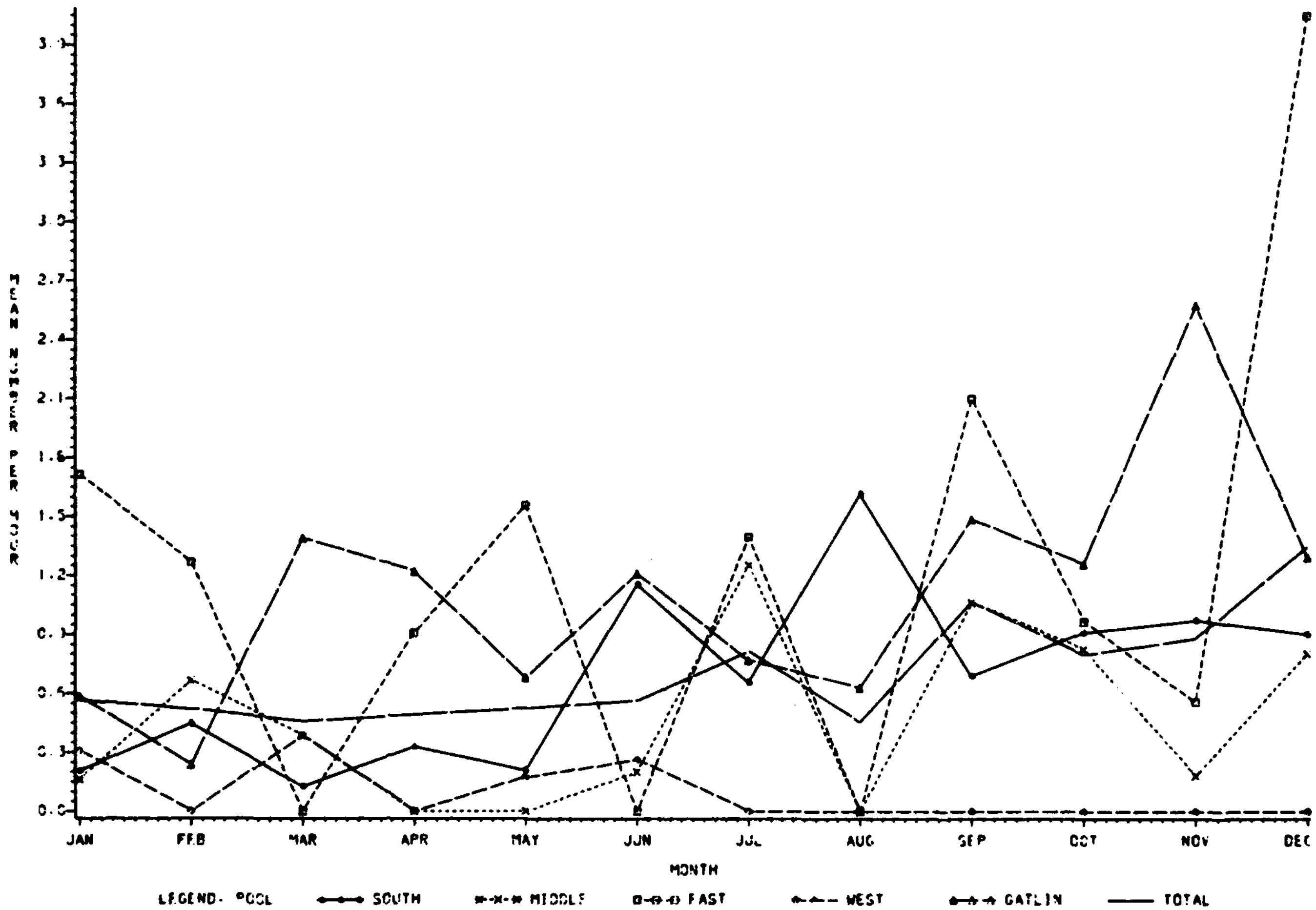

Figure 35. The mean number of <u>Pseudemys floridana</u> sighted per hour in each month on the permanent sites during the three-year study.

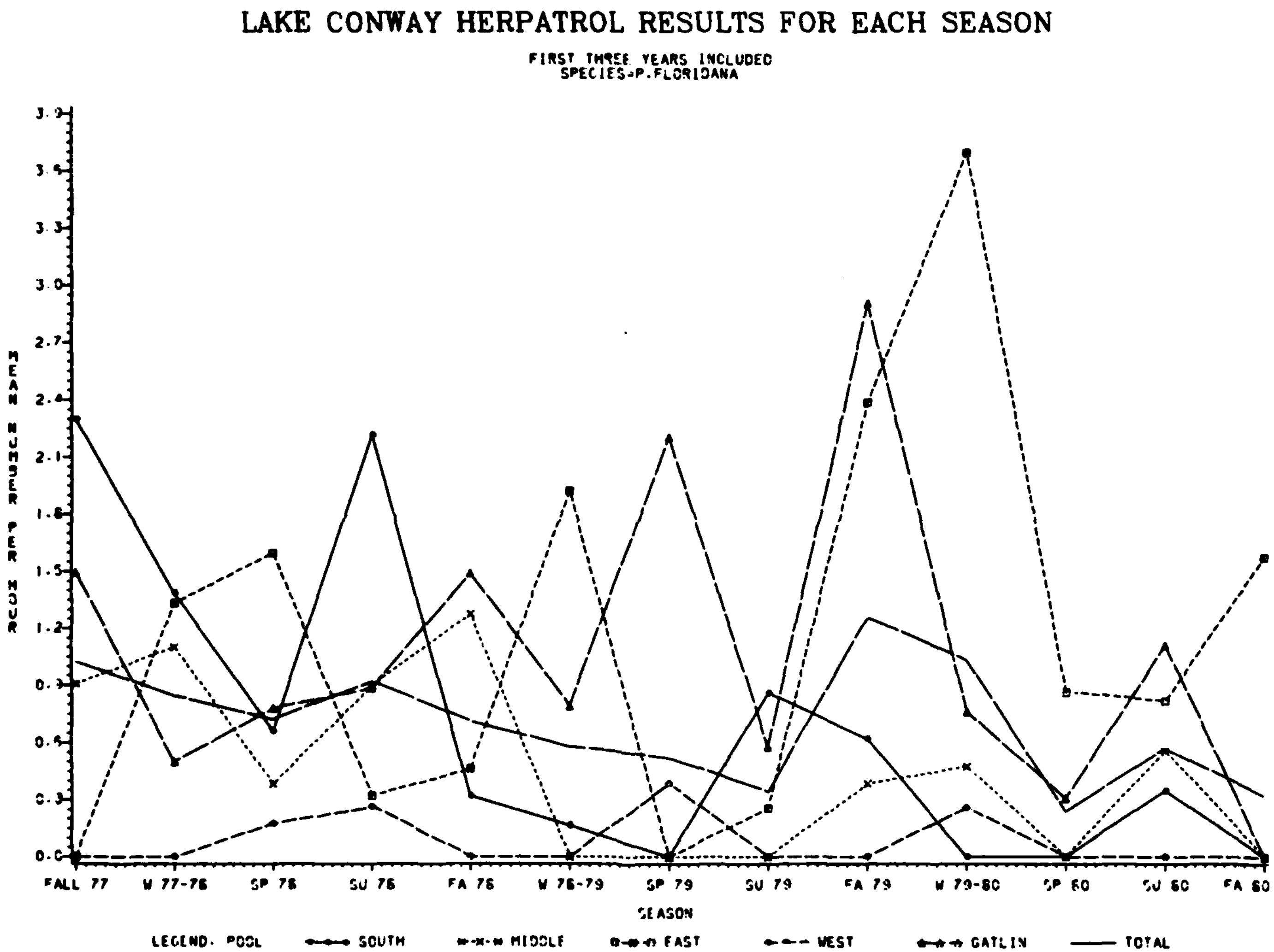

Figure 36. The mean number of Pseudemys floridana sighted per hour in each season on the permanent sites during the three-year study.

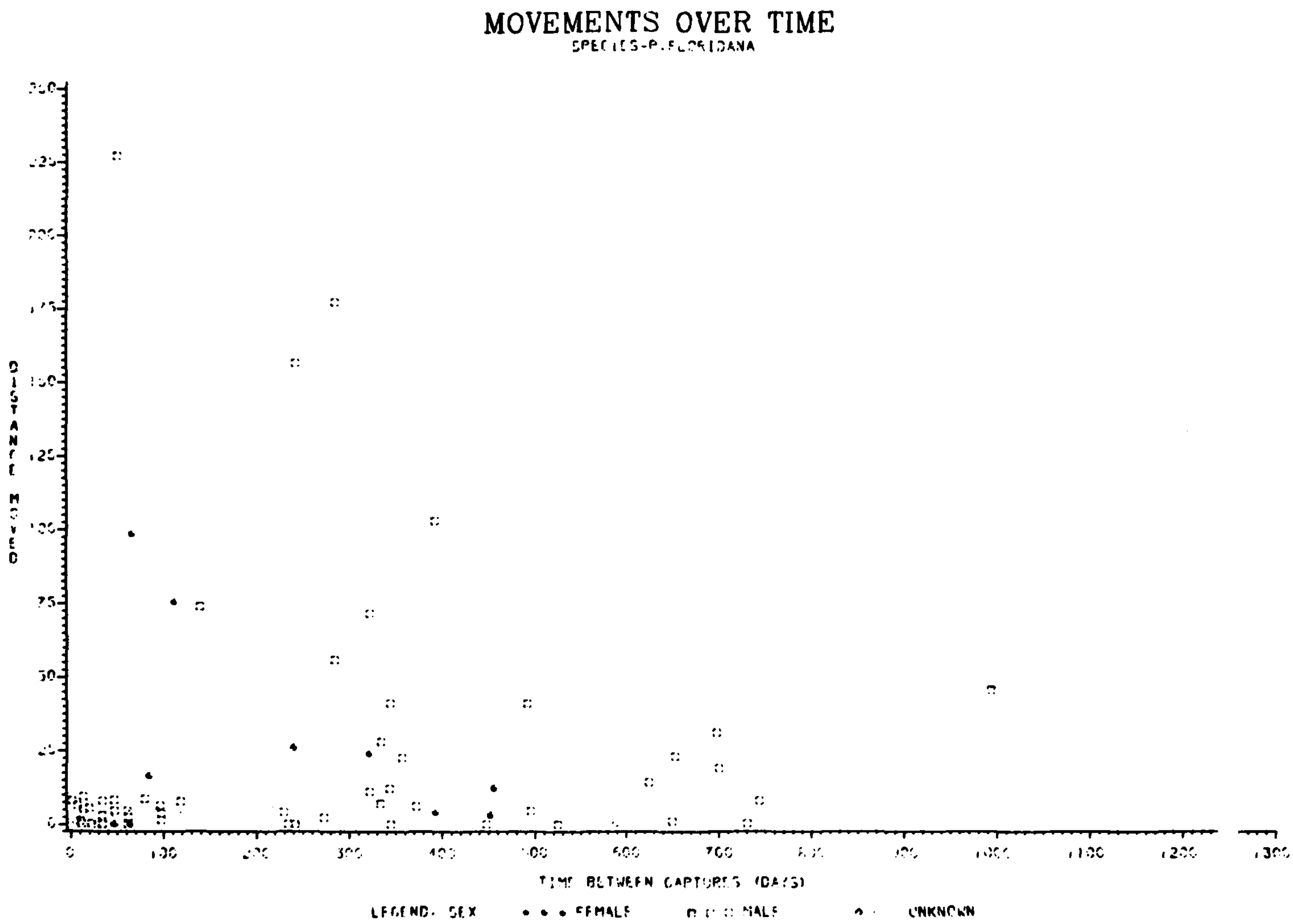

Figure 37. Relationship between time between captures and linear distance moved in *Pseudemys floridana*.

made up most of the summer's catch in South Pool. East Pool showed a different pattern with monthly rates highest in winter, especially in December (Fig. 36). This winter peak in activity occurred in all study years (Fig. 37). In East Pool large numbers of adult peninsular cooters spent winter nights beneath the water-hyacinth mats on the islands, often returning to open water habitats during the day. During other seasons adults frequented this littoral zone environment less often. Interpretation of these monthly herp-patrol results would not have been possible without extensive radiotelemetry work with this species in East Pool.

187. Movement information was available for 91 Pseudemys floridana recaptured 110 times. Three of these individuals moved between pools: one from Gatlin Canal to West Pool, and two from Gatlin Canal to East Pool; all others were recaptured in the same pool. In this sample, time between captures accounted for only 3.4% of the variance in linear distance moved (Fig. 38) and the model was not significant ($F=3.80$, $P>.05$). Removing time as a variable, a 3-way ANOVA showed no significant difference in the distance moved between the sexes ($F=1.86$, $P>.16$), pools ($F=3.80$, $P>.05$), or study years ($F=0.05$, $P>.83$). For some comparisons, the non-significant results probably were caused by small sample sizes and associated high variances. For example, among the sexes the mean linear distance between captures was 235.8 m. for females (N=11, 2SE=199.6 m.), 241.5 m. for males (N=53, 2SE=126.8 m.) but only 149.8 m. for juveniles (N=46, 2SE=111.1 m.). For 22 P. floridana initially sexed as juveniles and recaptured as adults (20 males, 2 females), the mean distance moved was 483.7 m. Six (27.3%) of these (all males) had moved more than 1 km. compared with only two males (4.7%), one juvenile (2.3%) and no females that moved that distance. These data suggest that on Lake Conway, juvenile P. floridana have relatively small home ranges; as these individuals approach maturity some wander great distances before establishing a new (and larger) home range.

Population demography

188. Functionally, Pseudemys floridana probably is the most important turtle species on Lake Conway. Outnumbered only by the small ($\bar{X}$ weight=45.1 g.) stinkpot, Sternotherus odoratus, peninsular cooters dominated the turtle biomass on the lake. In addition to their large size (to 5.7 kg.), adult P. floridana are herbivorous (see Food Habits) and consume large quantities of

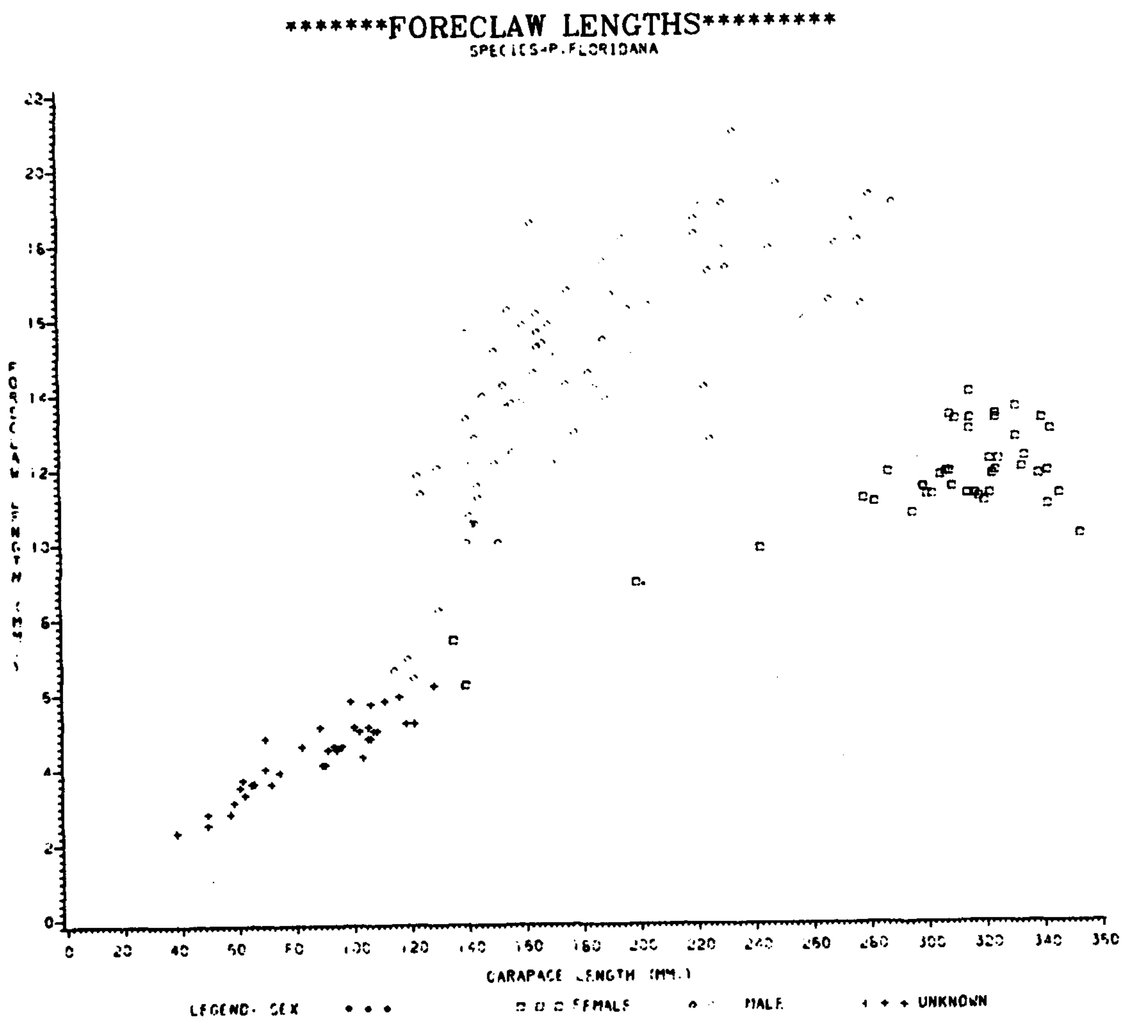

Figure 38. Relationship between carapace length and the length of the longest foreclaw in Pseudemys floridana from Lake Conway.

aquatic macrophytes in direct competition with the introduced white amur. For these reasons an understanding of their demography and population dynamics is important.

189. Peninsular cooters are sexually dimorphic in body size (see paragraph 191) and in several secondary characteristics (Ernst and Barbour 1972). Males have elongated foreclaws that are used in courtship displays and long, thick tails with the anal opening posterior to the carapacial margin. The elongation of foreclaws is under hormonal control and is correlated with the production of sperm in males (Evans 1952). We used foreclaw length as a means of determining the size at maturity of males and of distinguishing between the sexes (Fig. 38). Most males reached maturity at about 120 mm. CL and all males were mature by 140 mm. CL with foreclaw length ranging between 10.0 and 15.5 mm. The low percentage of intermediate specimens in this size range suggests that foreclaw elongation is rapid and may occur in a single season. Females showed no such allometry in foreclaw growth (Fig. 38), and matured at approximately 270 mm. CL (see Reproduction section).

190. In the Lake Conway study captured male Pseudemys floridana (N=263) outnumbered females (N=116) 2.27:1 (χ^2=57.02, P<.0001). No differences in sex ratio among study years were detected (χ^2=4.98, P>.05). The ratio of males to females varied with pool: South = 151 males:52 females (2.90:1), Middle = 46:20 (2.30:1), East = 44:30 (1.46:1), West = 7:7 (1:1), Gatlin = 15:7 (2.14:1). Only South and Middle were significantly different from a 1:1 sex ratio. This apparent biased sex ratio in favor of males may have resulted from at least five independent factors: (1) Males matured at a younger age than females (see Growth and Reproduction section), hence they were "sexable" for a greater duration of their lifespan; (2) Males spent more time than females in the shallow-water habitats at night (see paragraph 181). Thus, they were more likely to be recorded on herp-patrols; (3) Females were larger in body size and faster swimmers than males and thus were better at eluding capture. To examine this possibility, in SY2 and SY3 we field-sexed adult P. floridana that were approached closely but escaped. Criteria were body size and tail length which was visible in swimming turtles. Of the 100 adults that escaped, 64.0% were females, (4) A greater percentage (23.11%) of marked males (N=203) than females (7.63%, N=109) was recaptured (χ^2=13.05, P=<.001), (5) Temperature-dependent

sex determination in emydid turtles (e.g., Bull and Vogt 1979) may have biased the sex ratio in favor of males. At present the first three factors seem adequate to explain the apparent biased sex ratio. We suggest that the true sex ratio of P. floridana on Lake Conway approached one male to one female.

191. Figure 39 shows the size frequency distribution of all sexed Pseudemys floridana from Lake Conway during the first three study years. Turtles less than 120 mm. CL of known sex are preserved juveniles whose sex was determined by gonadal examinaton. The mean CL of 263 males (160.7 mm.) was much shorter than that of 116 females (264.0 mm.). In addition, the distributions are strongly skewed in opposite directions with males having a longer tail to the right of the mean (skewness = 0.51) and females a longer tail to the left (skewness = -1.10). The mode for male carapace length (142 mm.) was 141 mm. smaller than the maximum (283 mm.), but only 39 mm. smaller for females (mode = 312 mm., maximum = 351 mm.). These differences in carapace length also resulted in pronounced sexual differences in body mass. The average weight of females (2.96 kg.) was greater than the maximum weight of any male (2.45 kg.). Males averaged only 0.59 kg. in body mass but one female weighed 5.71 kg. These sexual differences in size structure appear most related to differences in the size and age of sexual maturity, and to subsequent growth patterns (see Growth and Reproduction section).

192. Tables 18, 19, and 20 present yearly and pool comparisons of the mean size of juvenile, male, and female Pseudemys floridana on Lake Conway. For juveniles, the only significant differences among pools occurred when all study years were lumped (Table 18). Small sample sizes in some pools (East and West) make interpretation difficult and suggest that the results may be a statistical artifact. For the three pools with the largest samples, juveniles were smallest in Gatlin ($\bar{X}$=67.0 mm. CL), intermediate in Middle ($\bar{X}$=72.4 mm. CL), and largest in South ($\bar{X}$=79.4 mm. CL). Males (Table 19) showed significant between-pool differences only in SY2, but again sample sizes were small. The pool means for all study years combined were not different (χ^2=3.80). Among females, between-pool differences in mean CL were detected in SY1, SY3, and in the yearly totals (Table 20). Although few in number, females were largest in West Pool ($\bar{X}$=339.4 mm. CL).

193. When all sexes of P. floridana were combined and summed over all

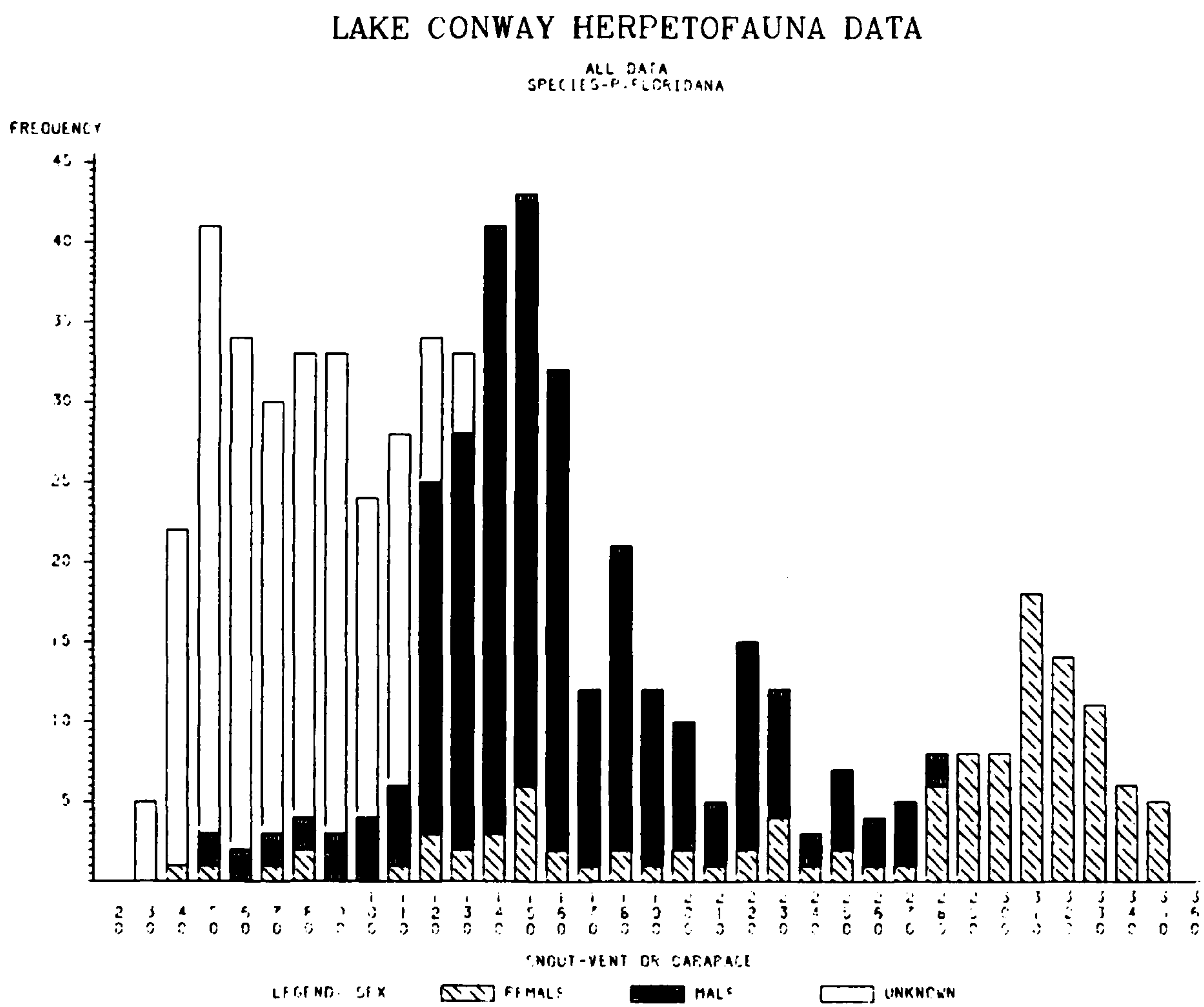

Figure 39. The size frequency distribution of Pseudemys floridana on Lake Conway.

Table 18

Mean carapace length in mm. of juvenile *Pseudemys floridana* collected on Lake Conway. Yearly and pool comparisons were based on the chi-square approximation of the Kruskal-Wallis test (KW). (* = P<.05, ** = P<.01, ns = not significant). If significant between-year or between-pool differences were detected (P<.05), pairwise comparisons were performed. Means with the same letter to the right of a value indicate no significant difference between those pools (P<.025); letters to the left of a value indicate no significant difference between those years (P<.025). See text for details.

	South Pool	Middle Pool	East Pool	West Pool	Gatlin Canal	Species Mean	KW
Study Year 1 (Sample Size)	76.6 (70)	74.0 (30)	A 51.2 (4)	69.5 (2)	66.4 (42)	72.4 (148)	8.85ns
Study Year 2 (Sample Size)	79.8 (19)	-	BA 135.0 (1)	64.0 (2)	66.9 (8)	77.2 (30)	4.13ns
Study Year 3 (Sample Size)	83.6 (43)	65.6 (7)	B 97.6 (5)	-	72.4 (5)	81.8 (60)	6.35ns
Mean for Years (Sample Size)	79.4 (132) AC	72.4 (37) AB	82.8 (10) C	66.8 (4) ABC	67.0 (55) B	75.4 (238)	13.11*
KW	2.58ns	0.22ns	7.36*	0.15ns	0.48ns	7.00*	

Table 19

Mean carapace length in mm. of male *Pseudemys floridana* collected on Lake Conway. Yearly and pool comparisons were based on the chi-square approximation of the Kruskal-Wallis test (KW). (* = P<.05, ** = P<.01, ns = not significant). If significant between-year or between-pool differences were detected (P<.05), pairwise comparisons were performed. Means with the same letter to the right of a value indicate no significant difference between those pools (P<.025); letters to the left of a value indicate no significant difference between those years (P<.025). See text for details.

	South Pool	Middle Pool	East Pool	West Pool	Gatlin Canal	Species Mean	KW
Study Year 1 (Sample Size)	147.9 (43)	163.0 (26)	152.8 (12)	177.0 (1)	140.5 (6)	A 152.9 (88)	2.68ns
Study Year 2 (Sample Size)	A 177.1 (33) A	127.6 (16) B	163.8 (11) AB	161.0 (1) AB	202.0 (1) AB	AB 162.1 (62)	11.68*
Study Year 3 (Sample Size)	A 165.4 (75)	153.8 (4)	172.6 (21)	144.6 (5)	174.9 (8)	B 166.1 (113)	2.07ns
Mean for Years (Sample Size)	163.0 (151)	149.9 (46)	165.0 (44)	151.6 (7)	162.9 (15)	160.7 (263)	3.80ns
KW	15.36**	5.48ns	2.14ns	2.83ns	0.76ns	6.21*	

Table 20

Mean carapace length in mm. of female *Pseudemys floridana* collected on Lake Conway. Yearly and pool comparisons were based on the chi-square approximation of the Kruskal-Wallis test (KW). (* = P<.05, ** = P<.01, ns = not significant). If significant between-year or between-pool differences were detected (P<.05), pairwise comparisons were performed. Means with the same letter to the right of a value indicate no significant difference between those pools (P<.025); letters to the left of a value indicate no significant difference between those years (P<.025). See text for details.

	South Pool	Middle Pool	East Pool	West Pool	Gatlin Canal	Species Mean	KW
Study Year 1 (Sample Size)	A 175.8 A (10)	213.6 A (13)	278.9 B (13)	345.0 AB (1)	278.0 AB (4)	A 234.6 (41)	12.02*
Study Year 2 (Sample Size)	BA 272.9 (7)	231.7 (3)	189.5 (6)	345.0 (1)	212 (1)	A 238.8 (18)	5.46ns
Study Year 3 (Sample Size)	B 286.3 A (35)	293.0 ABC (4)	287.2 AB (11)	337.2 C (5)	337.5 BC (2)	293.2 (57)	14.74**
Mean for Years (Sample Size)	263.3 A (52)	232.0 A (20)	264.1 B (30)	339.4 C (7)	285.6 ABC (7)	264.1 (116)	19.21**
KW	8.42*	3.30ns	4.52ns	0.15ns	4.02ns	12.18**	

study years, significant differences in mean carapace length between the pools become apparent (χ^2=61.38, P<.0001). The mean CL of animals from Gatlin (105.57 mm., N=77) was significantly smaller than those from Middle (138.04 mm., N=103) and South (145.34 mm., N=336) which were not different from one another but were smaller than specimens from East (190.60 mm., N=84) and West (205.78 mm., N=18) which were statistically the same.

194. In summary, male, female, and juvenile peninsular cooters varied significantly in body size among the pools, as did the entire sample. These differences reflect variation in size structure of P. floridana populations captured on herp-patrols in the five pools, but may not be representative of the entire system. Fortunately, only 35.63% of the P. floridana was taken from permanent sites (Tables A2, A3); thus, our results are based on a broad spectrum of the habitats available in each pool and accordingly our inference space is much greater than for many other species. As noted in the habitat analysis (paragraphs 180-182), the probability of capturing any size-sex category depended upon the habitat sampled. We suspect that variation in habitat quality alone produced most of the observed differences in body size among the pools.

195. Tables 18, 19, and 20 also show significant changes in the body size of juvenile, male, and female P. floridana among the study years. In all pools with adequate samples the results were similar: peninsular cooters in each of the size-sex categories increased significantly in mean carapace length from pre- to post-stocking periods. Because approximately the same areas were sampled in each pool in each year, the effects of sampling site biases were minimized. Again, we suspect that the observed variation was caused by changes in habitat quality which indirectly affected either reproduction, survivorship, growth rates, or habitat use in this species. Information presented below indicates that population densities of P. floridana declined on the permanent sites. No evidence exists to suggest that smaller individuals emigrated differentially from these sites. In fact, of the 24 P. floridana taken originally on the permanent sites and later recaptured, only three (12.5%) had moved elsewhere even though 64.37% of the total sample for this species was collected off these sites.

196. Table 21 shows the distribution of P. floridana size-sex categories

Table 21

The relative abundance of juvenile, male, and female *Pseudemys floridana* on Lake Conway in each study year.

	Juveniles	Males	Females	Total (%)
Study Year 1				
Observed	142	84	43	269
Expected	88.3	112.6	68.1	(37.41)
Chi-Square	32.7	7.3	9.2	
Study Year 2				
Observed	27	68	29	124
Expected	40.7	51.9	31.4	(17.25)
Chi-Square	4.6	5.0	0.2	
Study Year 3				
Observed	67	149	110	326
Expected	107.0	136.5	82.5	(45.34)
Chi-Square	15.0	1.1	9.2	
Total	236	301	182	719
(%)	(32.82)	(41.86)	(25.31)	(100.00)

by study year. The results were highly significant (χ^2=84.13, P<.0001) and changes in juvenile abundance account for 62.1% of the cell chi-squares. The trend was clear: the proportion of juveniles in the Lake Conway population decreased during the study. This same pattern emerged from permanent site captures (χ^2=63.76, P<.0001) where the percentage of juveniles in the sample decreased from 68.05% in SY1 to 28.13% in SY2 and 15.15% in SY3.

197. What demographic factor(s) are responsible for the change in the size structure of P. floridana populations on Lake Conway? At present, adequate information is not available to evaluate directly changes in yearly growth rates. However, by using covariance analysis (see paragraph 51 for rationale) it is possible to factor out the effects of differences in carapace length and to examine the relative body mass or "condition factor" of individuals from different pools or study years. Here we assumed that faster growing individuals would have larger fat deposits and hence weigh proportionately more than slow-growing individuals. The analyses showed no significant yearly effects for juveniles, males, or females, although males varied significantly in relative body mass among the pools (heavier in Gatlin and Middle, lighter in the other pools). Hence, we infer that grow rates did not change substantially among study years.

198. No reason exists to suspect that reproductive output per individual decreased during the study. Many local residents have observed P. floridana nesting on their property. They state that most nests were deposited on beaches or in flower beds where nest excavation would be relatively easy; nesting in lawns was rare, presumably because the dense sod inhibited digging. In addition, we suspect that nest success was higher on Lake Conway than in many of the more natural Florida settings. The urbanization of much of Lake Conway has reduced the populations of native nest predators such as raccoons, opossums, skunks, and otters which often destroy upwards of 95% of emydid nests (e.g., Moll and Legler 1971, Shealy 1976). In the few, relatively undisturbed regions of Lake Conway (e.g., East Pool islands) the remnants of emydid nests destroyed by predators were common; such findings were rare along more urbanized sections of shoreline.

199. However, once hatchling turtles leave the nest, survivorship and hence recruitment into the adult population may be very low. The habitat

analysis presented earlier (Table 15) indicated that, unlike males and females, juveniles showed no yearly shifts in dependence on the littoral zone even though this habitat decreased in abundance during the study. We infer that an intact littoral zone is required by juvenile P. floridana and that the loss of this preferred habitat lowered survivorship, presumably through increased rates of predation by fish, wading birds, etc. The concomitant reduction of near-shore macrophyte populations by white amur probably accentuated this trend but the relative contribution of each factor is unknown. No reason exists to suspect that our capture and marking techniques resulted in differential mortality of juveniles.

200. In summary, loss of littoral zone and near-shore macrophyte populations on Lake Conway appears to have affected differentially survivorship of juvenile Pseudemys floridana. Yearly decreases in recruitment of these juveniles into the adult population resulted in changes in the size structure of the species on the lake system. Juvenile P. floridana increased in mean size from 72.4 mm. CL in SY1 to 81.8 mm. by SY3 (Table 18). As fewer juveniles entered the adult population, the mean size of males (Table 19) and females (Table 20) also increased significantly.

201. In addition to changes in size structure, P. floridana also varied in relative density on herp-patrols on the permanent sites (Table A5). Summed over all years, densities were lower in West Pool than in all other pools which were not different statistically from one another. However the rank-order of relative densities of peninsular cooters on these sites varied with study year and some of these changes were significant (Table A5). Highest densities in SY1 were recorded in South, followed by Middle, East, Gatlin and West. In SY2 densities on the South and Middle Pool sites declined dramatically relative to the other sites. Both of these sites experienced considerable habitat destruction in this year (McDiarmid et al. 1983). In SY3, South and Middle Pools showed no improvement, and as a result relative densities were highest in East and Gatlin.

202. Significant yearly changes in the relative density of P. floridana within the permanent sites also were detected. In both South (χ^2=20.55, P<.0001) and Middle Pool (χ^2=10.50, P=.005), densities were significantly higher in SY1 than in SY2 or SY3, which were not different from one another.

The other pools showed no significant yearly changes, but the density declines in South and Middle caused the pool total to be significant (χ^2=8.06, P=.018). These significant yearly reductions in relative density were caused chiefly by the loss of juvenile P. floridana from the populations.

203. For many species the causes and relative importance of various mortality factors often were difficult to detect and quantify. The same is true of peninsular cooters. We have inferred that differential survivorship of juveniles relative to adult P. floridana largely was responsible for the observed changes in the size structure and relative density of this species on Lake Conway. Differential predation was assumed to be the major casual agent of these demographic changes.

204. Table 21 summarizes information on the 39 Pseudemys floridana found dead on Lake Conway during the study. These data must be interpreted with caution because for any given mortality factor both the probability of dying and the probability of being found dead vary with body size. Eleven P. floridana, including nine males and two females, were found partially eaten and presumably killed by either otters (Lutra canadensis) or raccoons (Procyon lotor). The smallest of these was 132 mm CL. We suspect that juveniles often are eaten by these and many other predators but are small or soft enough to be eaten whole or disarticulated beyond recognition. Most females are large enough to escape these predators; of the two found one was a young female (264 mm. CL), the other a gravid female (330 mm. CL) apparently killed while attempting to nest. The two juveniles eaten by birds were found on shore with peck marks; presumably most juveniles killed by birds are either eaten whole or carried off undetected.

205. Table 21 suggests that boat propeller strikes may be a major mortality factor of P. floridana on a lake receiving intense recreational use such as Conway. This factor accounted for 46.4% of the 28 deaths of known cause. To further examine the impact of boat-turtle confrontations, we scored all turtles for the presence and location of propeller wounds.

206. For the entire sample of 819 P. floridana from Lake Conway 21.12% had scars from boat propellers. Significant differences in the proportion of propeller-damaged turtles were found among the pools (χ^2=10.66, P=.0306). Those pools with the greatest recreational use (i.e., South, East, and West)

Table 22

The distribution of known or inferred mortality factors for *Pseudemys floridana* on Lake Conway.

Causal Agent	Juveniles	Males	Females	Unknown	Total
Boat propellers	1		10	2	13
Otter/raccoon		9	2		11
Bird	2				2
Middle ear infection		2			2
Unknown	4	1	3	3	11
Total	7	12	15	5	39

had higher percentages of damaged turtles (24.61%, 21.62%, 26.09%, respectively) than Middle (14.41%) or Gatlin (11.11%) which received comparatively little boat traffic.

207. Significant differences in the proportion of propeller-damaged individuals also were detected (χ^2=96.90, P<.0001) among juveniles (2.15% with damage, N=279), males (27.62%, N=344), and females (37.03%, N=189). These intraspecific differences probably were the result of three interrelated factors: age, body size, and habitat. Juvenile P. floridana clearly are younger than adults, and the mean age of mature males probably is less than the mean for females on Lake Conway (see paragraph 221). Because propeller strikes leave permanent scars the probability of receiving a detectable strike increases with age. In addition, as turtles grow older they also increase in body size and thus present a larger target to oncoming boats. Finally, previous habitat analyses (Tables 15-17) showed that the probability of finding an individual in the littoral zone or in near-shore shallows decreased from juveniles to males to females. Thus, females and larger males were most likely to encounter high-speed boats, which typically were restricted to the open water environments of Lake Conway.

208. The mean incidence of propeller-damaged Pseudemys floridana varied significantly among study years (χ^2=44.60, P<.0001): the percentage of individuals with wounds increased from 8.24% in SY1 to 21.62% in SY2 to 29.63% in SY3. This result is not surprising since the proportion of juveniles in the population decreased during the study (Table 21) and the mean body size (and presumably age) of males and females increased (Tables 19 and 20). Aside from these demographic biases, it is logical to assume that the incidence of propeller strikes (and deaths) is increasing on Lake Conway in proportion to the increase in recreational use of the lake and to the decrease in littoral zone habitat, which provides a refuge even for adult peninsular cooters.

209. Specific information on the particular scutes struck by boat propellers was available for 154 of the 175 P. floridana with propeller damage (Fig. 40). In general, the probability of receiving a strike increased from anterior to posterior scutes for marginals, vertebrals, costals, and plastral scutes. Most (76.25%) turtles were hit only on the carapace, 2.50% only on the plastron, and 21.25% showed damage to both elements. In addition, one or more

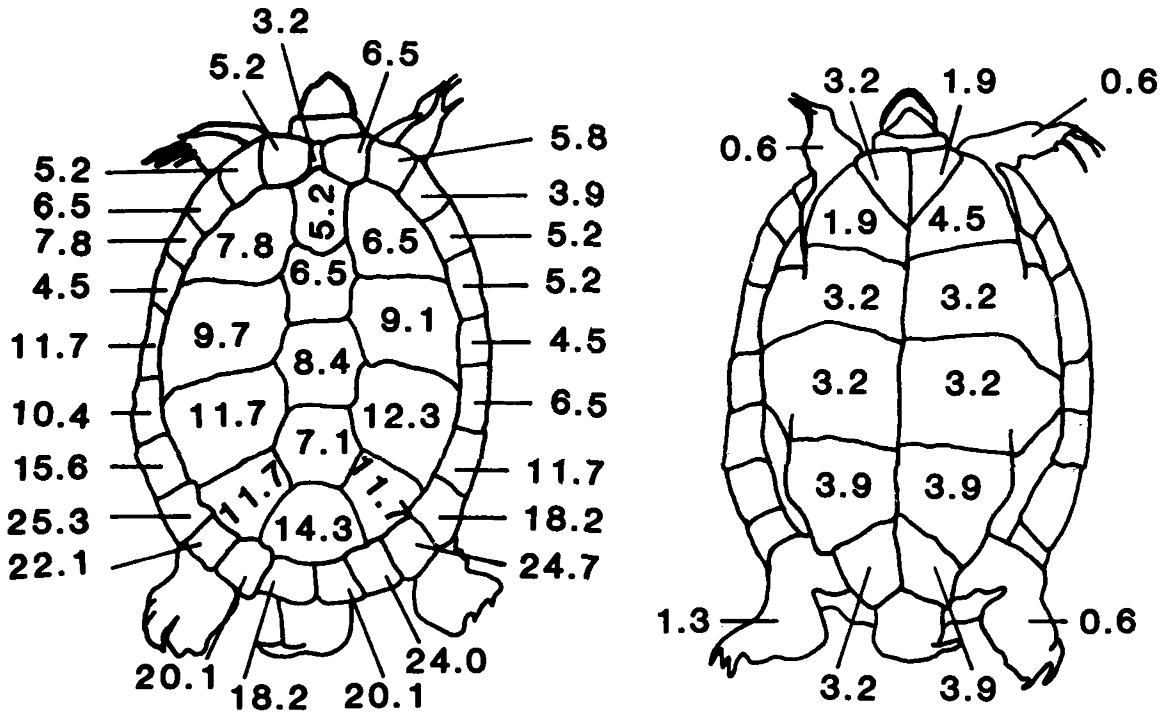

Figure 40. The distribution of boat propeller scars on Pseudemys floridana from Lake Conway. Values represent the percentage of propeller strikes on carapace and plastron of 154 scarred turtles.

limbs of 7 turtles (5.1%) were severed by boat propellers; posterior limbs were hit more often than anterior ones. We infer from these data that most P. floridana are struck while diving in an attempt to avoid oncoming boats. Most damage to plastral scutes probably occurred when the turtle was first hit on the carapace, and then flipped over to receive a second strike. In the 13 P. floridana found dead as a result of propeller strikes (Table 22), the carapace of all individuals was split open, often severing the spinal cord.

210. A minimum estimate of the probability of a P. floridana being hit by a boat propeller can be obtained by summing for all recaptured individuals the total number of turtle days between captures and dividing by the number of turtles known to have been struck between captures. This analysis assumes that propeller strikes always were recorded. Of the 91 recaptured P. floridana, 23 (25.27%) had propeller damage. Of these 23 individuals, 14 had the same propeller damage at first and last capture, and nine were struck between captures. None showed evidence of two separate propeller strikes between captures. Among those hit, one was an adult female, three were adult males, and five were juveniles without damage when captured originally. Four of these five were mature males with propeller damage upon recapture. Interestingly, three of these latter four were captured twice as undamaged juveniles, and one of the three adult males was very small (123 mm. CL) when originally captured, suggesting that attainment of sexual maturity with accompanying habitat shifts (paragraph 181) and wandering tendencies (paragraph 187) increased the probability of these individuals being hit by boats.

211. The sample of nine individuals had a mean yearly probability of 0.0945 of being hit (95% confidence limits = 0.0358 to 0.1532), or equivalently 10.58 years between strikes (95.26 turtle-years between captures/9 turtles). The mean yearly probabilities and 95% confidence limits were 0.0509 (0.0013 to 0.1005) for juveniles, 0.1058(0.0680 to 0.1436) for males, and 0.1607 (0.0 to 0.4491) for females. These values correspond to 19.95, 9.45, and 6.22 years between strikes, respectively, and are in agreement with the percentage of juveniles (2.15%), males (27.62%), and females (37.03%) in the populations with propeller damage. We emphasize that both of these are minimum estimates and probably grossly underestimate the actual probability of P. floridana being hit by a boat propeller on Lake Conway. We generally sampled only those

individuals that survived a strike; most animals killed by boats probably sank to the bottom undetected. For example, two of 46 radiotelemetried emydids (one P. floridana and one P. nelsoni) were known to have been killed by boats. Both individuals sank to the bottom, and the event would have gone unrecorded had not the radiotag and remains of the turtle been recovered.

212. Evolutionarily, turtles generally have opted for a long expected adult lifespan with multiple clutches of many eggs to counter low egg and hatchling survivorship (Bury 1979). Given the long time required for sexual maturity of male (five years) and of female (16 years) P. floridana on Lake Conway (see Growth and Reproduction section), and our high but minimum estimates of boat propeller strikes, survivorship of adult cooters on this lake system probably is very low. In addition, decreasing densities (Table A5) and changes in the population structure of cooters on Lake Conway (Table 21) suggest that recent recruitment has not been adequate to balance adult losses. Thus, we suspect that peninsular cooters are experiencing serious, and perhaps irreversible, population declines on Lake Conway. These demographic changes, largely caused by shoreline development and increased recreational use of the lake, probably were in effect prior to the LSOMT and at present show no signs of abatement. Introduction of white amur into the lake system probably accentuated these trends by removing much of the vegetated open water habitat and forage base (see Food Habits section) of P. floridana.

Food Habits

213. Seventy Pseudemys floridana from Lake Conway were available for dietary analysis (Table 23). Twelve (17.14%) of these individuals contained no food. The diet of the others was dominated by plant material which occurred in all individuals with food and accounted for 98.85% of the total prey biomass. At least eight species of plants were represented. Filamentous algae (Lyngbya sp.) was most common occurring in 74.1% of the individuals with food and accounting for 46.3% cf the total prey weight, followed by Vallisneria americana (56.9%, 33.3%), and Potamogeton illinoensis (25.9%, 617%). Hydrilla verticillata was found in only one individual; three contained Nitella megacarpa. For all categories of vascular plants, leaves were the most frequently ingested part and accounted for most of the plant biomass; stems and roots were rarely taken.

Table 23

The diet of 70 *Pseudemys floridana* from Lake Conway

Prey taxa	Number (%) of individuals containing prey taxa	Number (%) of prey taxa	Weight (%) of prey taxa in g.
EMPTY	12 (17.1)		
TOTAL VEGETATION	58 (82.9)		504.4 (98.8)
Filamentous algae	43 (61.4)		236.0 (46.3)
Nitella megacarpa	3 (4.3)		34.7 (6.8)
Nymphaea odorata	1 (1.4)		0.1 (0.1)
Potamogeton illinoensis	15 (21.4)		34.0 (6.7)
Vallisneria americana	33 (47.1)		170.1 (33.3)
Vegetative matter	12 (17.1)		6.1 (1.1)
TOTAL ANIMALIA	20 (28.6)	133 (100.0)	5.9 (1.2)
Bryozoa	3 (4.3)	4 (3.0)	1.4 (0.3)
Decapoda	7 (10.0)	8 (6.0)	1.2 (0.2)
Trichoptera	8 (11.4)	113 (85.0)	2.8 (0.5)
Other animals	3 (4.3)	8 (6.0)	0.5 (0.1)

214. Twenty of the 68 P. floridana with food contained animal matter representing at least 12 taxa. Tricopteran larvae, bryozoans, and crayfish were most important accounting for 48.9%, 24.0%, and 20.0% respectively, of the biomass of animal prey. Slight ontogenetic shifts in the relative importance of animal matter in the diet were detected. Of 41 P. floridana less than 150 mm. CL with food in their stomach, 39.0% contained animal prey compared with 23.5% of 17 individuals longer than 150 mm. CL. The relative biomass contribution of animal prey was similar in the two size classes (1.6% and 6.2%, respectively).

215. Table 24 shows the known diet of peninsular cooters on Lake Conway in each of the three study years (N=33 individuals from SY1, 23 in SY2, and 14 in SY3). Although sample sizes were small, the relative importance in the diet of Potamogeton illinoensis seemed to decrease whereas Vallisneria americana increased. Filamentous algae, and plant material in general, were important components in all study years. The single P. floridana with Hydrilla verticillata in its gut (not shown in Table 24) was collected in SY2.

216. The stomach analyses clearly indicate that on Lake Conway Pseudemys floridana is chiefly herbivorous. The Florida DNR has shown that four species of plants (Hydrilla verticillata, Potamogeton illinoensis, Nitella megacarpa, and Vallisneria americana) accounted for over 99% of the macrophyte biomass on Lake Conway and that the distribution and abundance of these plants changed following the introduction of white amur (Schardt et al. 1981).

217. To examine the potential effects of white amur on emydid turtle populations, the following food preference experiment was conducted. Sixteen cages (1 m. x 2 m. x 1 m.) constructed of 6 mm. mesh Vexar netting (Du Pont De Nemours & Co., Model No. 60-CDS-49-BABK) were placed in a shallow pond near the University of South Florida in January 1982. Each cage was stocked with a single adult emydid turtle (eight P. floridana, eight P. nelsoni; four of each sex) and two bundles each of H. verticillata, P. illinoensis, N. megacarpa, and V. americana, each weighing approximately 250 g. All turtles and plants were collected from Lake Conway in early February. Each day for six days (4-9 February) each plant bundle was weighed and the amount eaten replaced to insure that availability did not change. Water temperature ranged from 20 to 22 °C during this experiment. Thus, the experimental design provided each turtle

Table 24

The diet of *Pseudemys floridana* in each study year.

	Empty	Filamentous algae	Nitella megacarpa	Potamogeton illinoensis	Vallisneria americana	Total vegetation	Total Animalia
Study Year 1							
Number (%) of individuals containing prey	6(18.2)	21(63.6)	1(3.0)	12(36.4)	15(45.5)	27(81.8)	1(3.0)
Weight (%) of prey taxa in g.		73.6(43.7)	0.5(0.3)	33.9(20.1)	28.9(17.2)	168.5(99.9)	0.1(0.1)
Study Year 2							
Number (%) of individuals containing prey	3(13.3)	14(60.9)		3(13.0)	11(47.8)	20(87.0)	10(43.5)
Weight (%) of prey taxa in g.		80.2(75.9)		0.2(0.2)	22.7(21.4)	103.5(98.8)	2.3(2.2)
Study Year 3							
Number (%) of individuals containing prey	3(21.3)	8(57.1)	2(14.3)		7(50.0)	11(78.6)	3(21.4)
Weight (%) of prey taxa in g.		82.3(34.8)	34.2(14.5)		118.5(50.2)	234.0(99.5)	1.2(0.5)

with a super abundance of the four common macrophytes on Lake Conway, and examined food preferences among these plant species.

218. For Pseudemys floridana, significant differences (F=5.11, P=.0019) in food preference were detected. The mean wet mass eaten per day of H. verticillata (21.6 g.) and V. americana (23.6 g.) was not different and, both plants were preferred over N. megacarpa (13.3 g.) and P. illinoensis (9.1 g.). These results probably overestimated the daily amount of N. megacarpa eaten. Unlike the other three plant species, this algae was extremely fragile. Pieces of N. megacarpa often were torn off by the movements of turtles; these sank to the bottom of the cage and were not recorded. Pieces from other plant species floated and were added back to the bundles prior to weighing.

219. Table 23 shows that in 58 P. floridana with food, filamentous algae (Lyngbya sp.) was the most frequently ingested plant (61.4%) and contributed most to the prey biomass (46.3%), followed by V. americana (47.1%, 33.3%), P. illinoensis (21.4%, 6.7%), and N. megacarpa (4.3%, 6.8%). Only one individual contained H. verticillata. The field and experimental results were not congruent for several reasons: (1) Schardt et al. (1981: Fig. J7-J10) showed that the percent coverage of the four dominant macrophytes varied by species and by pool. For the total lake system in 1977 and 1980 respectively, N. megacarpa was most abundant (185.4 ha., 251.6 ha.), followed by P. illinoensis (183.0 ha., 48.0 ha.), H. verticillata (78.0 ha., 1.1 ha.), and V. americana (40.0 ha., 87.3 ha.). Thus, plant availability, which changed during the study, had an important influence on the diet of field-collected animals; (2) Filamentous algae, which was not recorded by DNR or tested for feeding preference in the experiments, were ubiquitous on lake Conway and actually may have dominated the macrophyte biomass in some pools; (3) the limited sample of P. floridana (N=70, Table 23) was taken primarily from Middle (45.5%) and East Pools (44.2%), pools with historically small populations of H. verticillata (Schardt et al. 1981: Fig. J7). Thus, the apparent rarity of this plant in the diet probably reflects its low availability to the turtles in these pools.

220. In summary, the diet of peninsular cooters in Lake Conway was dominated by plant material. Adults of this turtle preferred H. verticillata and V. americana over P. illinoensis or N. megacarpa, but plant availability strongly influenced the diet. The relatively small samples of turtles in each

year were not adequte to evaluate yearly shifts in the diet of *P. floridana* on Lake Conway. However, the clear preference of peninsular cooters for hydrilla and the virtual removal of this plant by white amur suggest that competitive interactions between the fish and turtle species may have been strong in some pools. Presumably, *P. floridana* switched to other, less preferred plant species when hydrilla was eliminated from the lake system. The ecological consequences of this dietary shift are unknown, but probably important. In a laboratory study Pearse et al. (1926) showed that painted turtles (*Chrysemys picta*) grew faster on a mixed diet than when fed either component separately. This finding may be universal among generalist herbivores (Westoby 1974) and suggests that removal of hydrilla by white amur may have reduced the growth rate (and perhaps the reproductive output) of individual *P. floridana* on Lake Conway. In addition, selective grazing of young, nutrient-rich shoot tips of any aquatic plant (e.g., Bjorndal 1979, Dawes and Lawrence 1979, Mattson 1980) by white amur also may have negatively affected the net energy and mineral balance of peninsular cooters on the lake system.

Growth and Reproduction

221. Of the 521 peninsular cooters marked on Lake Conway, 91 (17.5%) were recaptured 110 times. Estimates of growth rates were available for 69 of these individuals whose capture dates were more than 90 days apart. Significant differences in mean growth rate were detected among the sexes ($F=3.13$, $P<.05$), but not among pools or among study years (F tests for each size-sex category). The mean growth rate per year was 3.09 mm. CL for 6 females, 7.78 mm. CL for 38 males, and 12.26 mm. CL for 25 juveniles that were still juveniles when recaptured. In addition, 18 individuals initially captured as juveniles had matured (17 males, 1 female) prior to recapture; their mean growth rate per year was 13.82 mm. CL and not significantly different from that for juveniles. Based on an average juvenile yearly growth rate of 12.91 mm. CL and the knowledge that hatchlings average 34 mm. CL, then males would reach mature size in about six years (120 mm. CL) and females would require more than 15 years to reach minimum reproductive size (270 mm. CL).

222. To avoid possible seasonal biases, we recalculated growth rates using only those individuals ($N=48$) captured more than 300 days apart ($\bar{X}=658.2$ days). Mean growth rates in mm. CL per year were 3.64 for 3 mature females,

7.71 for 21 mature males, 17.51 for 6 juveniles, and 13.24 for 17 juveniles later captured as adults. Based on this sample, the average male P. floridana from Lake Conway would mature within five years of hatching and females would require about 16 years.

223. These estimates of minimum age at sexual maturity seem excessive compared with other emydid turtle species. Based on Bury's (1979) review of the demography of 19 emydid populations (nine species), the mean minimum age at maturity was 4.27 years for males (mode=3, range=2-10) and 6.33 years for females (mode=4, range=4-14). Most of these species were carnivores or omnivores. The only comparative information available for Pseudemys floridana is Gibbons and Coker's (1977) study of this species in South Carolina. On the basis of 19 individuals with distinct plastral growth rings, they tentatively concluded that male P. floridana may mature at age three years and females at an age of six or seven years. Unfortunately, growth rings of peninsular cooters from Lake Conway never were legible beyond the fourth ring (i.e., an individual's third winter). Based on growth ring analysis (see Moll and Legler 1971, Gibbons 1976 for methods) juvenile P. floridana on Lake Conway average at the end of their first, second, and third winter 54.3, 71.20, and 88.10 mm. plastron length (=PL) respectively, for a mean yearly growth rate of 16.88 mm. PL. This estimate is slightly lower than the mean based on recaptures (18.39 mm. PL/yr.). Jackson (1964) studied growth in a Crystal River, Florida, population of the closely-related congener, Pseudemys concinna, but did not provide age at sexual maturity for this herbivorous species. Re-analysis of his extensive growth records indicate that male P. concinna mature at five years of age with females delaying maturity until approximately 16 years of age. This suggests that P. floridana and P. concinna from Florida have similar, slow growth rates.

224. Why are peninsular cooters growing at such slow rates on Lake Conway? Gibbons (1970) and Christy et al. (1974) showed that Pseudemys scripta inhabiting a reservoir receiving heated effluent grew faster and matured earlier (four versus eight years for females) than populations from nearby, natural ponds. Parmenter (1980) studied these same populations and showed that 31.25% of the prey biomass of reservoir turtles was animal material compared to 21.04% for turtles from natural ponds. He concluded that the higher protein

diet of reservoir turtles was responsible for their increased growth rates; water temperature differences were of secondary importance. On Lake Conway only 1.15% of the prey biomass of P. floridana was animal material (Table 23). We suggest that the low protein diet of these turtles was responsible for their low growth rates which, in turn, directly affected the time required to reach sexual maturity. Importantly, P. concinna also is herbivorous and exhibits similar growth rates and age at sexual maturity (Jackson, 1964). The only other herbivorous turtle for which growth and age at sexual maturity in natural populations has been determined is Gopherus polyphemus (Landers et al. 1982); this species requires 16-21 years to mature.

225. On Lake Conway no evidence exists to suggest that animal material (protein content) increased in importance in the diet of peninsular cooters during the study (Table 24). In addition, it is reasonable to conclude that white amur reduced both the absolute abundance and diversity of macrophytes on the lake system (Schardt et al. 1981). Because P. floridana is chiefly herbivorous (Table 23), growth rates of this turtle species actually may have been depressed during the study, either through a reduction in the quality of forage eaten or through an increase in the cost of foraging as patches of quality habitat became rarer.

226. Reproductive information based on preserved specimens was available for 50 male and 21 female P. floridana; of these, 20 males were larger than 120 mm. CL and four females were larger than 270 mm. CL. Previous analyses (Fig. 38) showed that male foreclaw elongation, and hence attainment of sexual maturity begins at about 120 mm. CL with all males possessing elongate foreclaws by 140 mm. CL. Examination of male gonads confirm these general findings but seasonal and intraspecific variation in the wet masses of testes and epididymides makes a more precise determination difficult. The distribution of six males with enlarged testes (>1.3 g.) was March (1), September (4), and November (1); nine males with enlarged epididymides (>0.6 g.) were collected in March (1), April (1), May (2), September (4), and November (1). In emydid turtles, testicular enlargement typically occurs at the height of spermiogenesis; testicular regression follows the expulsion of spermatozoa into the epididymides, which in turn regress following mating (Moll 1979). Thus, based on these limited morphological data, most mating in P.

floridana probably would occur in spring or fall. Although copulation was not observed on Lake Conway, courtship behavior in this species was seen on numerous occassions during September, but rarely in other months. From these behavioral observations we believe that September is the peak month for mating in *P. floridana* on Lake Conway.

227. Eight gravid female *P. floridana* were collected on Lake Conway during the months of January (3), February (1), March (1), October (1), and November (2). *P. floridana* eggs also were found in the field in September and December. In addition, four females used for feeding experiments from mid-January through July 1982 (see paragraph 217) deposited clutches in March (3), April (3) and June (1). Two of these latter individuals laid clutches in March and again in April, 12 and 17 days apart, respectively. These findings are in agreement with the literature for *P. floridana* from Florida (review by Iverson 1977): gravid or nesting females have been collected from September through June. A July-August hiatus in reproduction is suspected (D. R. Jackson, pers. comm.). Females are known to deposit at least two clutches per year (Iverson 1977, present study). However, the apparent long nesting season suggests that some individuals may lay 4-6 clutches of eggs per year. Carapace length in the 11 gravid *P. floridana* from Lake Conway ranged from 283 to 343 mm. However, D. Jackson (pers. comm.) found that the minimum size of reproduction for females of this species from north-central Florida was 270 mm. CL: we assume this also is true of Lake Conway animals. Clutch size and carapace length (in parentheses) of five *P. floridana* from Lake Conway were 6, 9 (324 mm., one individual), 10, 13 (343 mm., one individual), 12 (318 mm.), 12 (320 mm.), 19 (322 mm.); nine additional literature records reported a range from 10 to 21 eggs (Iverson, 1977) for a mean clutch size of 13.75 eggs (N=16) for the species. Possibly because of small sample sizes, no annual variation in reproduction in *P. floridana* from Lake Conway was detected.

Pseudemys nelsoni (Florida red-bellied turtle)

Distribution and Habitat Preferences

228. Florida red-bellied turtles were the third most abundant turtle species on Lake Conway accounting for 4.68% of the chelonian catch and 1.89% of

the total herpetofaunal sample (Table A2). Less than half (46.02%) of the individuals were taken on permanent sites (Tables A2, A3). Most (83.19%) observations of this species were on herp-patrols (Table A1).

229. The distribution of Pseudemys nelsoni provides an interesting contrast with the only other native congener on the lake system, P. floridana. The relative abundances of the two emydid species were significantly different among pools (χ^2=84.65, P<.0001; Table A2) and among permanent sites (χ^2=32.12, P<.0001; Table A3). Gatlin and South Pools contributed most to chi-square with proportionately fewer P. nelsoni than expected in South Pool and more than expected in Gatlin (Table 25); the same general distributional pattern occurred on the permanent sites.

230. These distinct distributional differences among two congeneric turtle species suggest that their habitat requirements may differ. To facilitate comparisons of habitat preferences between the species, analyses similar to those given previously for P. floridana were performed for P. nelsoni. Table 26 shows the yearly distribution of P. nelsoni in three open water habitats (none was seen over Nitella megacarpa) and in the littoral zone. Of 120 individuals with habitat information, 82.50% were taken in the littoral zone compared with only 46.58% of the P. floridana. In addition, the mean distance that animals were sighted from the outer edge of the littoral zone vegetation towards shore was much greater for P. nelsoni ($\overline{X}$=3.47 m.) than P. floridana ($\overline{X}$=2.45 m.). Unlike P. floridana, no significant yearly shifts in habitat usage were detected for P. nelsoni (χ^2=4.37, P=.82) although some trends were similar, e.g., the percentage of individuals observed in the littoral zone decreased from 90.63% in SY1 to 80.00% in SY2 to 78.79% in SY3 as this habitat decreased in abundance on the lake system. No significant yearly shifts in habitat use were detected within pools, or for juveniles, males, or females; in all of these comparisons small sample sizes may have masked any yearly differences that existed. In addition, no significant differences in littoral zone use occurred between juvenile, male, and female P. nelsoni (χ^2=1.56, P>.45); the proportion of each size-sex category found within the littoral zone was 84.0% for 25 juveniles, 69.6% for 23 males, and 80.0% for 30 females. Again, small sample sizes may have contributed to this non-significant result.

Table 25

Chi-square analysis of the distribution of two emydid turtle species on Lake Conway summed over all years.

	South Pool	Middle Pool	East Pool	West Pool	Lake Gatlin	Total (%)
Pseudemys floridana						
Observed	470	136	161	25	109	901
Expected	411.7	151.1	171.9	28.0	138.3	(79.95)
Chi-square	8.2	1.5	0.7	0.3	6.2	
Pseudemys nelsoni						
Observed	45	53	54	10	64	226
Expected	103.3	37.9	43.1	7.0	34.7	(20.05)
Chi-square	32.9	6.0	2.7	1.3	24.8	
Total	515	189	215	35	173	1127
(%)	(45.70)	(16.77)	(19.08)	(3.11)	(15.35)	(100.00)

Table 26

Habitat analysis of the yearly distribution of *Pseudemys nelsoni* on Lake Conway.

	Potamageton illinoensis	Vallisneria americana	Bare bottom	Littoral zone	Total (%)
Study Year 1					
Observed	1	1	1	29	32
Expected	1.9	1.1	2.4	26.4	(26.67)
Chi-square	0.4	0.0	0.8	0.3	
Study Year 2					
Observed	4	1	5	44	54
Expected	3.2	1.8	4.1	45.4	(45.83)
Chi-square	0.2	0.4	0.2	0.0	
Study Year 3					
Observed	2	2	3	26	33
Expected	1.9	1.1	2.5	27.2	(27.50)
Chi-square	0.0	0.7	0.1	0.1	
Total (%)	7 (5.83)	4 (3.33)	9 (7.50)	99 (82.50)	119 (100.00)

231. Interestingly, the species of littoral zone plants used by the two emydid species varied significantly (χ^2=11.53, P<.05). Whereas P. nelsoni rarely frequented Panicum hemitomon, P. floridana was common in this habitat (Table 27); the reverse order of preference occurred for the floating macrophyte, Nymphaea odorata (Table 27), a plant frequently eaten by P. nelsoni but not by P. floridana (See respective Food Habits sections). The proportion of each turtle species found in Eichhornia crassipes, Nuphar luteum, Typha latifolia, and other plant species were similar and contributed little to chi-square.

232. These vegetation analyses suggest that Pseudemys nelsoni is more dependent upon an intact littoral zone than P. floridana, a species which spends much time in open water environments. The preferred habitats of P. nelsoni on Lake Conway can be stated as follows: densely vegetated littoral zones resembling marsh habitat in physiogonomy, and quiet backwaters and sloughs resembling alligator holes. These habitat preferences probably explain most of the differences in distribution and relative abundances of these two emydid species on the lake. For example, P. nelsoni was relatively uncommon in South Pool compared to P. floridana (Table A2). However, the relative abundances of the two species varied with habitat in this pool: in 7-11 Cove, the only quiet backwater on South Pool (see McDiarmid et al. 1983, paragraph 27) the ratio of P. floridana to P. nelsoni was 4.26:1; along the shoreline of the rest of South Pool, which was mainly beach habitat, the ratio was 11.45:1. In Gatlin Canal, which in many ways resembled an alligator trail, the ratio of peninsular cooters to red-bellied turtles was 2.09:1 (Table A3).

233. Historically, P. nelsoni was probably much more abundant on Lake Conway than today. Conversion of most of the littoral zone to beach front property on this lake system in recent years has eliminated most of the suitable habitat for this species and increased its rate of decline relative to P. floridana. Accordingly, we expect that P. nelsoni will continue to decrease in abundance on Lake Conway.

Activity Patterns

234. Only one red-bellied turtle was taken in funnel traps and little is known of their diel activity cycles. The species is known to feed and move during both the night and day. Perhaps because P. nelsoni was relatively

Table 27

Chi-square analysis of the distribution of *Pseudemys floridana* and *P. nelsoni* in littoral zone habitats on Lake Conway.

	Eichhornia crassipes	*Nuphar luteum*	*Nymphaea odorata*	*Panicum hemitomon*	*Typha latifolia*	Other species	TOTAL (%)
P. floridana							
Observed	21	115	46	34	35	7	258
Expected	21.0	112.7	54.9	27.5	34.0	7.9	(72.27)
Chi-square	0.0	0.0	1.5	1.6	0.0	0.1	
P. nelsoni							
Observed	8	41	30	4	12	4	99
Expected	8.	43.3	21.1	10.5	13.0	3.1	(27.73)
Chi-square	0.0	0.1	3.8	4.1	0.1	0.3	
TOTAL	29	156	76	38	47	11	357
(%)	(8.12)	(43.70)	(21.29)	(10.64)	(13.17)	(3.08)	(100.00)

uncommon on Lake Conway monthly trends in activity were difficult to detect (Fig. 41). Summed over all pools, months, and study years, the mean number of P. nelsoni observed per hour on herp-patrols was 0.26. The mean per season summed over all study years and pools was 0.184 P. nelsoni/hr. in winter, 0.338/hr. in spring, 0.218/hr. in summer, and 0.275/hr. in fall. Converted to percentages and compared with P. floridana, results are as follows: winter = 18.1% P. nelsoni, 28.8% P. floridana; spring = 33.3%, 17.2%; summer = 21.5%, 21.4%; fall = 27.1%, 32.6%. Thus P. nelsoni is most commonly seen in spring and P. floridana in fall and winter.

235. Yearly seasonal trends in P. nelsoni activity are not readily apparent (Fig. 42). The highest number seen per hour occurred in Gatlin Canal in the spring of 1979; similar peaks were not observed in other years.

236. Movement information based on recaptures of 25 marked P. nelsoni were available. One juvenile moved from East Pool to Gatlin Canal (2.82 km.) in 31 days and one male moved from Gatlin Canal to West Pool (0.52 km.) in 923 days; all other recaptures were from the same pool. Figure 43 shows the relationship between distance moved and time between captures for 25 C. nelsoni; the regression was not significant (F=0.20, P>.66). No significant size-sex differences (F=0.41, P>.67) were detected in the mean linear distance moved for 10 females ($\bar{X}$=175.6 m., 2SE=115.1 m.), 8 males ($\bar{X}$=216.7 m., 2SE=224.3 m.) and 10 juveniles ($\bar{X}$=321.3 m., 2SE=531.1 m.). Summed over all individuals of P. nelsoni the mean distance moved between captures was 239.5 m. (2SE=198.7 m.) which was slightly greater than the mean (263.7 m.) for P. floridana (2SE=79.2 m.).

Population Demography

237. Like peninsular cooters, Florida red-bellied turtles are sexually dimorphic in body size and in foreclaw length (Fig. 44). During the period when foreclaw length was routinely measured (September 1980 - May 1982) relatively few small male P. nelsoni were collected. By 160 mm. CL all of these males had greatly elongated foreclaws (17-25 mm. in length). However smaller males collected earlier in the study before foreclaws were routinely measured were clearly distinguishable from young females (Fig. 44). Based on this sample, most male P. nelsoni reach sexual maturity between 140 and 160 mm. CL. Like P. floridana, female P. nelsoni show no allometry in foreclaw growth;

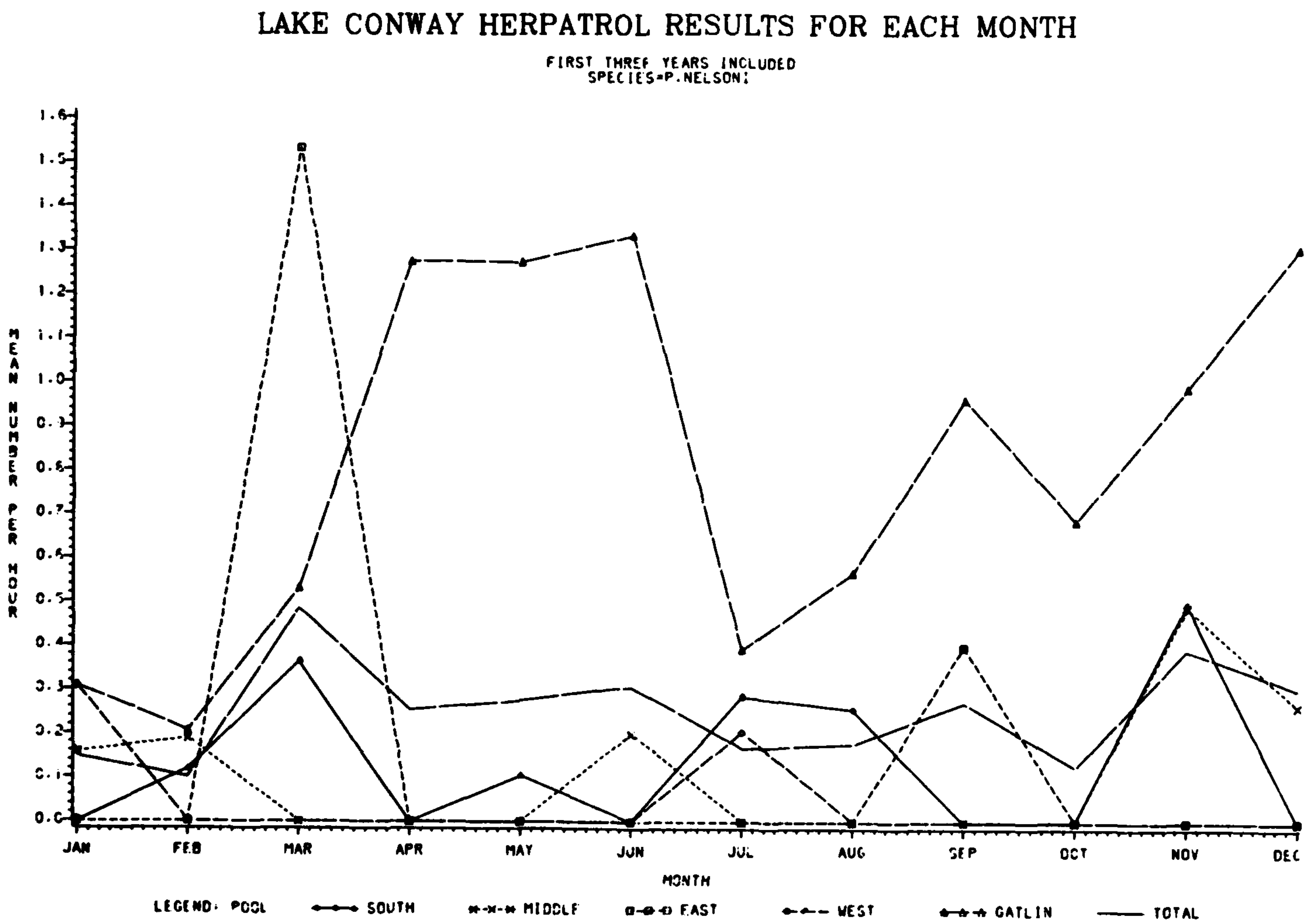

Figure 41. The mean number of Pseudemys nelsoni sighted per hour in each month on the permanent sites during the three-year study.

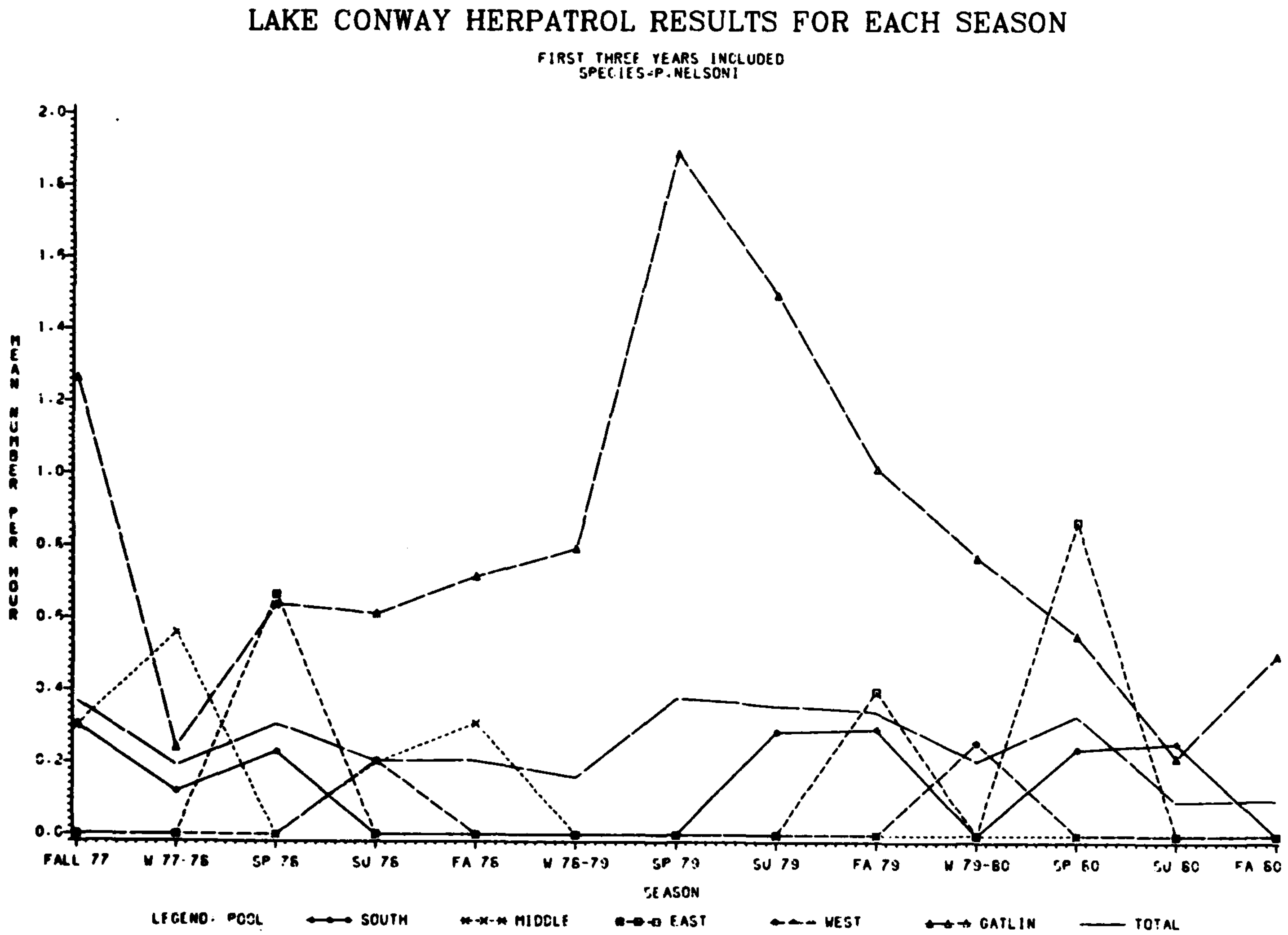

Figure 42. The mean number of Pseudemys nelsoni sighted per hour in each season on the permanent sites during the three-year study.

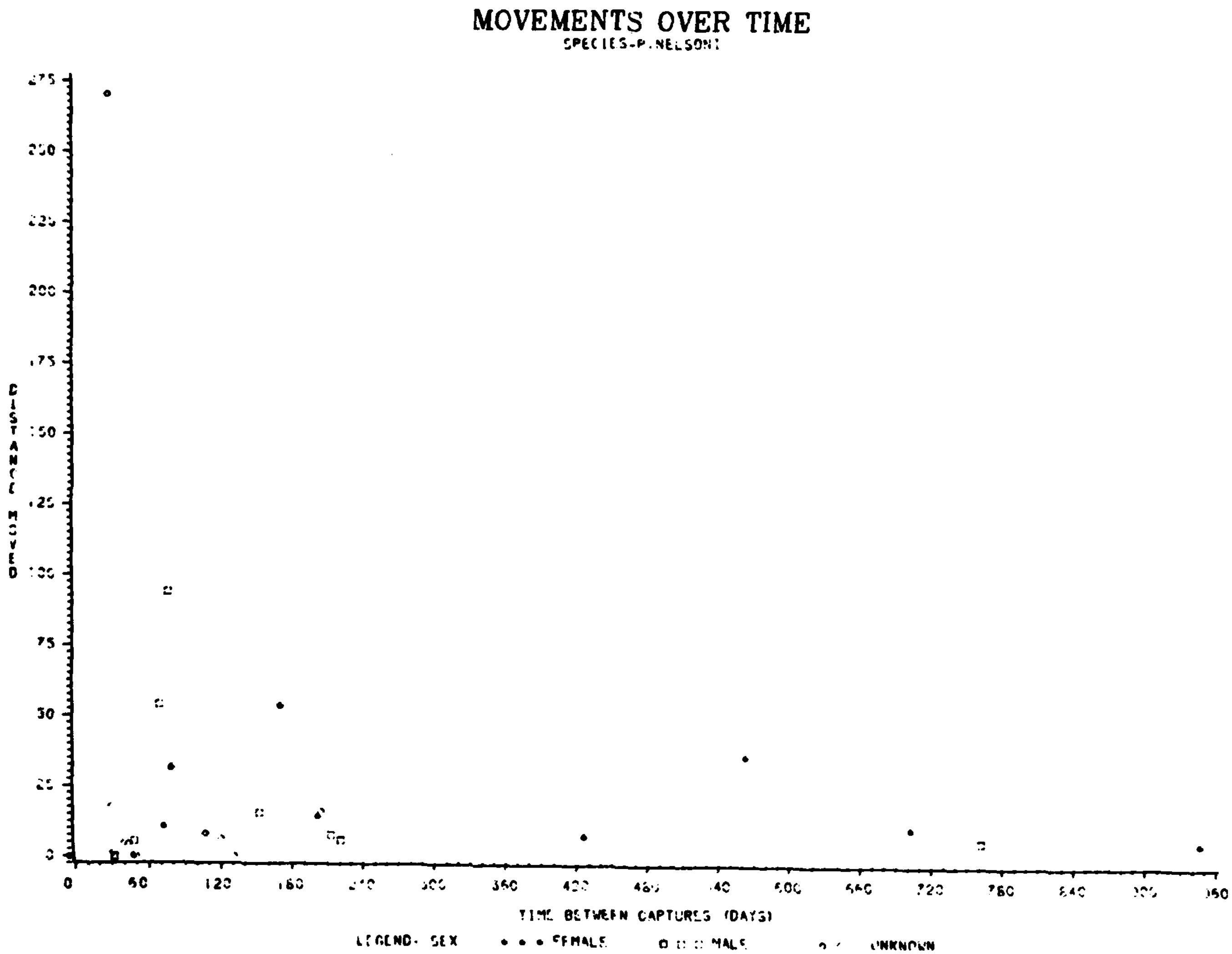

Figure 43. Relationship between time between captures and linear distance moved in *Pseudemys nelsoni*.

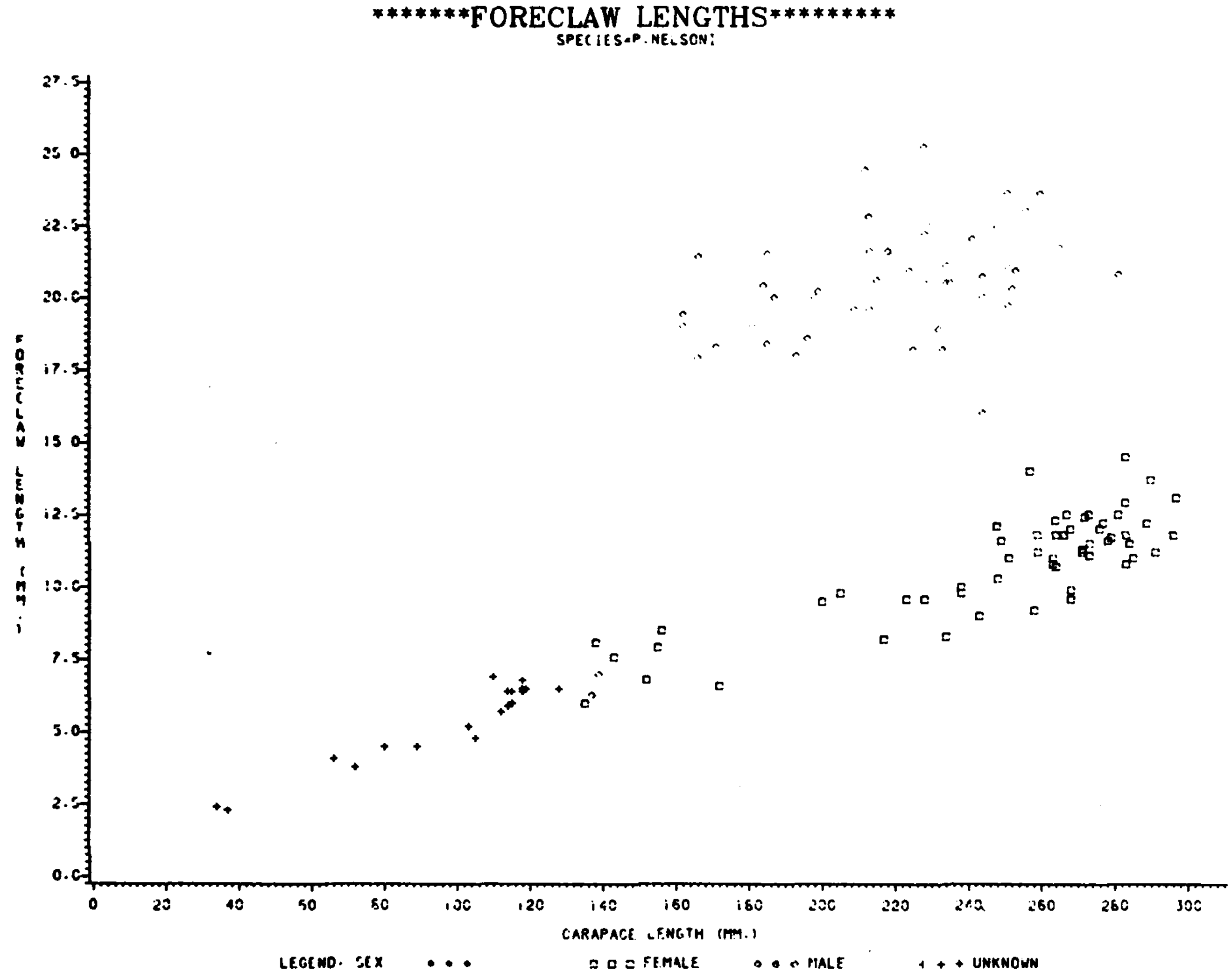

Figure 44. Relationship between carapace length and the length of the longest foreclaw in Pseudemys nelsoni from Lake Conway.

females mature at about 270 mm. CL (see Growth and Reproduction section).

238. Unlike P. floridana, the sex ratio of captured P. nelsoni (53 females: 30 males = 1.77:1) was skewed in favor of females (χ^2=6.37, P<.05), and a similar ratio was found among field-sexed red-bellied turtles (see paragraph 190 for sexing criteria). No difference in sex ratio between the study years was detected (χ^2=1.923, P=.382). Again, we suspect that sexual differences in ecology and susceptibility to capture account for the apparent bias in sex ratio.

239. Pseudemys nelsoni is sexually dimorphic in body size (Fig. 45) with 30 males averaging 167.5 mm. CL. (mode=161 mm., maximum=233 mm.) and 50 females 221.7 mm. CL (mode=270 mm., maximum=309). Males averaged 0.79 kg. in body mass compared to 1.96 kg. for females; the maximum recorded weights were 1.78 kg. for males and 4.10 kg. for females. Thus on Lake Conway the mean and maximum body size of P. nelsoni was smaller than that of P. floridana (see paragraph 191).

240. Table 28 summarizes yearly and pool differences in the mean carapace length of Pseudemys nelsoni on Lake Conway. In this analysis all size-sex categories were lumped and West Pool was eliminated from the pool comparisons because of small sample sizes. The analysis shows that summed over all study years P. nelsoni averaged largest in size in East Pool, intermediate in South and Middle, and smallest in Gatlin. Interestingly, this same rank-order of mean size by pool also occurred in P. floridana (paragraphs 192-193). For both species we suspect that variation in habitat quality among the pools resulted in differences in population size structure and hence, mean body sizes.

241. No significant differences were detected in the mean carapace length of red-bellied turtles among study years (Table 28). This result may be because no yearly changes in size structure occurred or because sample sizes were not adequate. Table 29 shows the distribution of P. nelsoni size-sex categories by study year which can be compared directly with Table 21 for P. floridana. Table 29 suggests that no yearly changes in the size structure of P. nelsoni occurred (χ^2=8.62, P>.05), although the proportion of juveniles increased from 22.3% in SY1 and 24.1% in SY2 to 56.3% of the sample in SY3. Whereas most juvenile P. nelsoni were taken on permanent sites in SY1 (83.9%) and SY2 (100.0%), in SY3 77.8% were obtained off these sites. These sampling

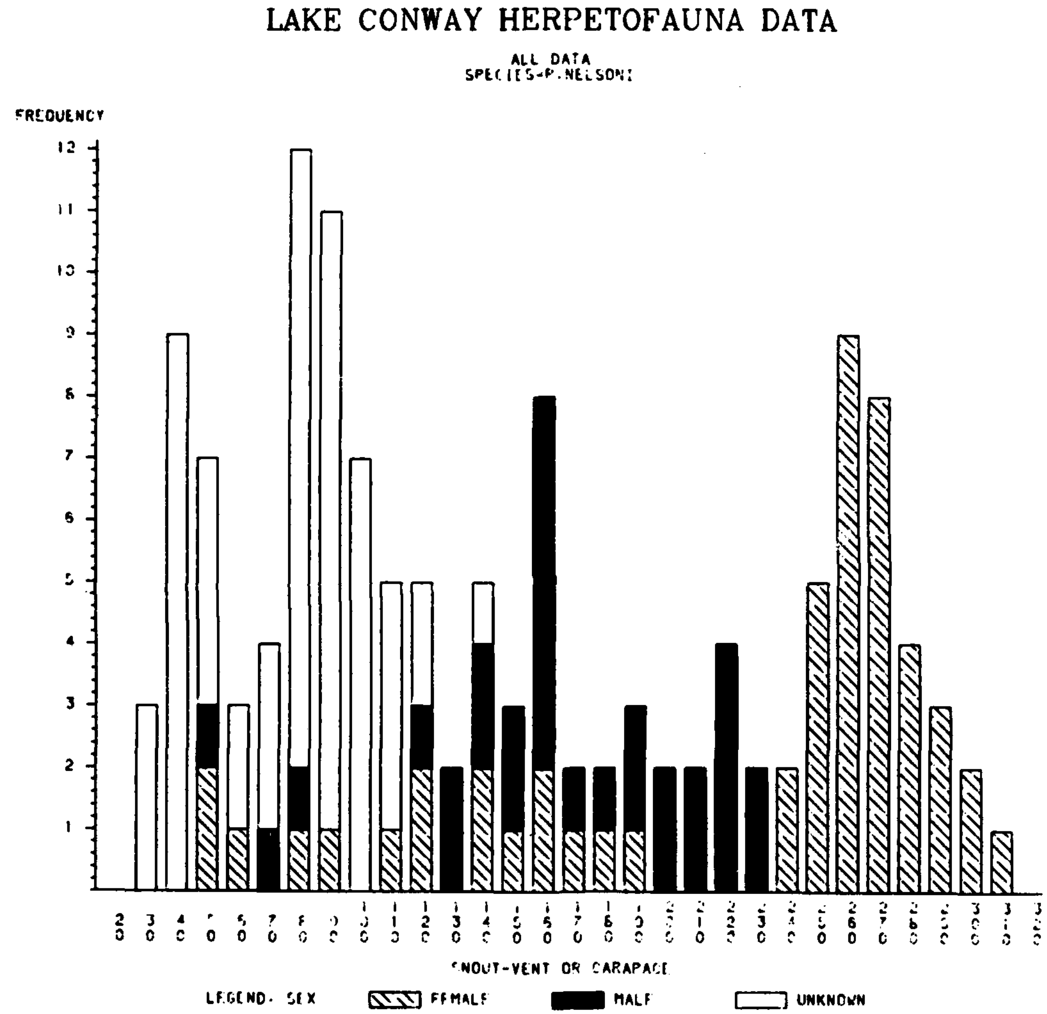

Figure 45. The size frequency distribution of Pseudemys nelsoni on Lake Conway.

Table 28

Mean carapace length in mm. of *Pseudemys nelsoni* on Lake Conway. Yearly and pool comparisons were based on the chi-square approximation of the Kruskal-Wallis test (KW). (* = $P<.05$, ** = $P<.01$, NS = not significant). If significant between-year or between-pool differences were detected ($P<.05$), pair-wise comparisons were performed. Means with the same letter to the right of a value indicate no significant difference between those pools ($P<.025$); letters to the left of a value indicate no significant difference between those years ($P<.025$). See text for details.

	South Pool	Middle Pool	East Pool	West Pool	Gatlin Canal	Species Mean	KW
Study Year 1	139.3	153.1	196.2	270.0	116.9	147.0	8.44 ns
(Sample Size)	(16)	(25)	(11)	(1)	(23)	(76)	
Study Year 2	185.4	133.8	275.7	200.0	142.7	168.4	7.99 ns
(Sample Size)	(7)	(4)	(3)	(1)	(13)	(28)	
Study Year 3	136.0	137.5	167.1	216.5	93.8	144.2	3.48 ns
(Sample Size)	(9)	(8)	(8)	(2)	(4)	(31)	
Mean for Years	148.5_{A}	147.6_{AB}	196.5	225.8+	123.0_{B}	150.8	12.97 *
(Sample Size)	(32)	(37)	(22)	(4)	(40)	(135)	
KW	1.20 ns	0.45 ns	5.25 ns		0.96 ns	1.49 ns	

+ West Pool not included in analysis because of sample size

Table 29

The relative abundance of juvenile, male, and female *Pseudemys nelsoni* on Lake Conway in each study year.

	Juveniles	Males	Females	Total (%)
Study Year 1				
Observed	31	14	33	78
Expected	31.4	16.8	29.7	(56.12)
Chi-Square	0.0	0.5	0.4	
Study Year 2				
Observed	7	10	12	29
Expected	11.7	6.3	11.1	(20.86)
Chi-Square	1.9	2.2	0.1	
Study Year 3				
Observed	18	6	8	32
Expected	12.9	6.9	12.2	(23.02)
Chi-Square	2.0	0.1	1.4	
Total	56	30	53	139
(%)	(40.29)	(21.58)	(38.12)	(100.00)

site differences accounted for most of the between-year variation in population structure. When a similar analysis was performed for only permanent site P. nelsoni, the distribution of size-sex categories was stable from year to year (χ^2=4.82, P>.30); juveniles accounted for 34.7%, 38.9%, and 30.8% of the sample in each of the respective study years.

242. The apparent absence of any yearly changes in the size structure of Pseudemys nelsoni on Lake Conway provides an instructive comparison with P. floridana, a species which experienced marked yearly increases in the mean size of juveniles, males, and females (Tables 18-20), and concomittant reductions in the relative abundance of juveniles (Table 21). Why should these congeners inhabiting the same lake system respond differentially with regard to population size structure? Previous habitat and demographic analyses suggested that juvenile P. floridana were dependent upon the littoral zone for survival whereas adults were capable of switching to alternate, open water environments as the littoral zone decreased in abundance and quality. This behavioral and ecological plasticity may not be present for P. nelsoni of any size or sex. Habitat analysis for this species (Table 26) showed that most individuals were restricted to the littoral zone with less than 20% of the entire sample observed in open water. If red-bellied turtles are as habitat specific as the data suggest, then they may show no response to environmental changes regardless of sex or size.

243. Table A5 summarizes yearly and pool differences in the mean relative density of P. nelsoni on permanent site herp-patrols. Significant between-pool differences were detected in SY1, SY2, and for all study years combined. In general, densities were highest in Gatlin Canal, intermediate in South, Middle and East, and lowest in West. No significant yearly differences were detected in any pool, or for all pools combined (χ^2=1.51, P>.47), possibly because of the low absolute abundance of this species on the lake system.

244. Florida red-bellied turtles seem to suffer from the same mortality factors that afflict Pseudemys floridana on Lake Conway. Eight P. nelsoni were found dead during the study. Four individuals (three females and one juvenile) were killed by boat propellers, one juvenile was killed and partially eaten by a river otter (Lutra canadensis), and one female was killed attempting to nest, probably by an otter or a raccoon (Procyon lotor). Two

radiotelemetried animals were found dead: one male was struck by a boat, and one female entangled her radiotag on fishing line and drowned.

245. Similar analyses of boat propeller strikes as provided for Pseudemys floridana (see paragraphs 205-211) were performed for P. nelsoni, since boats seem to be the major mortality factor for this species as well. The percentage of 282 P. nelsoni from Lake Conway with propeller damage (14.82%) was significantly less (χ^2=5.51, P=<.025) than that found in 819 P. floridana (21.12%). Such differences between the species were expected since P. nelsoni spends more time in the littoral zone (Table 26) than P. floridana (Table 13), and thus avoids most boats.

246. Many of the trends in propeller damage found in Pseudemys floridana also occurred in P. nelsoni. Although no significant differences in the proportion of propeller-damaged size-sex classes of P. nelsoni were detected, a higher percentage of adult males (15.85%) and females (18.18%) had damage than juveniles (7.69%). Pools with the greatest boat traffic and recreational use (South, East, and West) had significantly higher percentages of damaged individuals (26.92%, 15.38%, and 40.00%, respectively) than Middle Pool (7.32%) or Lake Catlin (0.0%), which received comparatively little boat traffic (χ^2=17.58, P=.0015). No significant differences in the incidence of propeller-hit P. nelsoni were detected among the study years (χ^2=5.38, P=.1461). Among the 45 P. nelsoni with boat propeller scars, specific scute information was available for 35 individuals. Trends were again similar to those recorded for P. floridana (see paragraph 209): (1) most P. nelsoni (83.78%) were hit only on the carapace, 16.22% had damage to both plastral and carapacial elements, and none was struck only on the plastron; and (2) posterior scute elements were more likely to be hit than anterior ones.

247. Only one of 30 recaptured P. nelsoni was struck by a boat between captures. The individual was marked initially as a juvenile (100 mm. CL) and recaptured 2.53 years later as an adult male (163 mm. CL) with propeller damage. Based on this small sample of recaptured individuals, the mean yearly probablity of a P. nelsoni being struck on Lake Conway is 0.0462 (95% confidence limits = 0.0 to 0.1346), or equivalently, 21.66 years between strikes. This estimate is much lower than the grand mean for P. floridana (10.58 years between strikes), and is in accord with the lower percentage of

propeller-damaged individuals and littoral zone habitat preferences of P. nelsoni. As mentioned previously (paragraph 244) one of 21 radiotagged P. nelsoni was known to have been killed by a boat propeller.

Food Habits

248. Only 21 Pseudemys nelsoni were available for dietary analysis (Table 30). Plant material occurred in all individuals with food and accounted for 99.74% of the biomass. In terms of the percent of turtles with food and the plant's biomass contribution to the diet respectively, the most important species were Vallisneria americana (38.9%, 18.2%), Nymphaea odorata (27.8%, 32.8%), and Cabomba caroliniana (22.2%, 34.8%). Potamogeton illinoensis and filamentous algae (Lyngbya sp.) occurred in several of the stomachs (33.3% and 27.8% but contributed relatively little to food biomass (3.3% and 7.3%, respectively). Four individual animal prey, including an oligochaete, a naiad of an odonate, a tricopteran, and a lepidoptera, also were identified from stomach contents. These animal prey were found in the 12 P. nelsoni less than 150 mm. CL.` No yearly shifts in food habits of this species were apparent.

249. Experiments on the food preferences of Pseudemys nelsoni were conducted simultaneously with those for P. floridana (see paragraph 217 for methods). Highly significant differences ($F=38.91$, $P<.0001$) in food preference also were detected for P. nelsoni. Unlike the results obtained for P. floridana (see paragraph 218), the mean wet mass of Hydrilla verticillata eaten per day by P. nelsoni (68.8 g.) was significantly greater than the mean for Vallisneria americana (38.4 g.). The means for Nitella megacarpa (13.4 g.) and Potamogeton illinoensis (10.8 g.) were not significantly different from one another but were lower than the means for H. verticillata or V. americana.

250. Food preferences of P. nelsoni in these experiments did not match those obtained from field collected individuals (Table 29). The reasons probably are similar to those given for P. floridana (see paragraph 219), namely plant availability at the sites where P. nelsoni were taken for food habit analysis, and the absence of certain plant species from the experiments. For example, those individuals that contained Cabomba caroliniana and Nymphaea odorata were collected in quiet coves where these plant species were common and H. verticillata and V. americana were absent.

Table 30

The diet of 21 Pseudemys nelsoni from Lake Conway.

Prey taxa	Number (%) of individuals combining prey taxa	Weight (%) of prey taxa in g.
EMPTY	3 (14.3)	
TOTAL VEGETATION	18 (85.7)	233.47 (96.7)
Cabomba caroliniana	4 (19.0)	81.39 (34.8)
Filamentous algae	5 (23.8)	17.11 (7.3)
Nuphar luteum	3 (14.3)	4.19 (1.8)
Nymphaea odorata	5 (23.8)	76.71 (32.8)
Potamogeton illinoensis	6 (28.6)	7.81 (3.3)
Vallisneria americana	7 (33.3)	42.81 (18.3)
Vegetative matter	6 (28.6)	3.45 (1.5)
TOTAL ANIMAL	2 (9.5)	0.61 (0.3)

Growth and Reproduction

251. Of the 151 red-bellied turtles marked on Lake Conway, 30 (19.9%) were recaptured 36 times. The mean yearly growth rate in CL for 17 individuals captured more than 90 days apart was 3.58 mm. for four mature females, 3.72 mm. for four mature males, and 19.29 mm. for nine juveniles (including five that matured between captures). However, most of these juveniles were recaptured over the winter when growth rates were slowest; for the four taken more than 300 days apart the mean growth rate was 28.56 mm. CL per year.

252. Fortunately, growth rings on plastral scutes of P. nelsoni remain legible for more years than those on P. floridana (see paragraph 223). Two hatchling P. nelsoni from Lake Conway were 31 mm. PL. By the end of their first through fifth winters respectively, mean plastron lengths were 71.37 mm. (N=30), 116.42 mm. (11), 162.94 mm. (5) 184.36 mm. (3), and 208.54 mm. (1); these values correspond to mean carapace lengths of about 75 mm., 126 mm., 177 mm., 201 mm., and 227 mm. at age five years. Thus, male P. nelsoni would mature in about three years. Assuming that females grew about 15 mm. in CL per year after age five, then they should mature between seven and eight years of age.

253. Only 21 preserved P. nelsoni from Lake Conway were available for reproductive studies. No seasonal patterns were discernible from the eight males. Four of the females provide reproductive information. A 246 mm. CL female (probably six years old) collected in September contained several 6-7 mm. follicles. No corpora lutea were present and her oviducts were small, suggesting that she was immature but may have been capable of reproducing the following year. A 276 mm. CL female was found nesting on 13 June. She deposited 11 eggs, and had an additional 13 enlarged ovarian follicles (15-21 mm. in diameter). Two 292 mm. CL. female P. nelsoni were collected in May. One contained 13 follicles (13-14 mm. in diameter), and the other had two sets of enlarged follicles (14 ova were 19-20 mm., 12 ova were 13-16 mm.). In addition, two females (290 mm. and 283 mm. CL) were found gravid in July and August, respectively (both were released). Iverson (1977) reported two clutches of 12 eggs from females taken in the months of May and August for this species. D. Jackson (pers. comm.) found that the nesting season of P. nelsoni in north-central Florida extended from May through August with several clutches

deposited each year. Based on these data, we suspect that on Lake Conway adult female P. nelsoni (>270 mm. CL) deposit several clutches of eggs from May through August of each year.

Pseudemys scripta (Red-eared turtle)

Distribution and Habitat Preferences

254. Pseudemys scripta was one of two non-native turtle species collected on Lake Conway. Judging from descriptions of the various subspecies of P. scripta (Conant 1975) and the individuals captured on Lake Conway, multiple introductions of this common pet-trade turtle have occurred. Some individuals are referrable to P. s. elegans and some to P. s. scripta; others appear to be intergrades. Including the fourth study year, five individuals were observed from South Pool, ten from East Pool, and one from West Pool. The species probably occurred in the other pools as well. Most (N=12) specimens were collected by herp-patrol or during telemetry trips but the species also was taken during shoreline censuses, in drift fences, in funnel traps, and by muddling (Table A1).

255. P. scripta appears to occupy a broad range of habitats on Lake Conway. Most specimens (N=14) were collected in Eichhornia crassipes, Typha latifolia or Panicum spp. near shore but two were found offshore, in beds of Vallisneria americana and Potamogeton illinoensis. One was taken in a small isolated pond along the shore of South Pool.

Activity patterns

256. Little is known about the activity patterns of P. scripta on Lake Conway. Six were captured during the daytime and seven at night (entrance times of the three taken in traps were unknown). Specimens were collected in all seasons with no apparent trends. No individuals were recaptured or radiotagged, thus movement patterns are unknown.

Population demography

257. Figure 46 shows the size-frequency distribution of P. scripta from Lake Conway. Although hatchlings were not collected, several size classes were represented in the sample. The lack of recaptures and cryptic habits of the species suggest that it may be more common than our samples indicate. P.

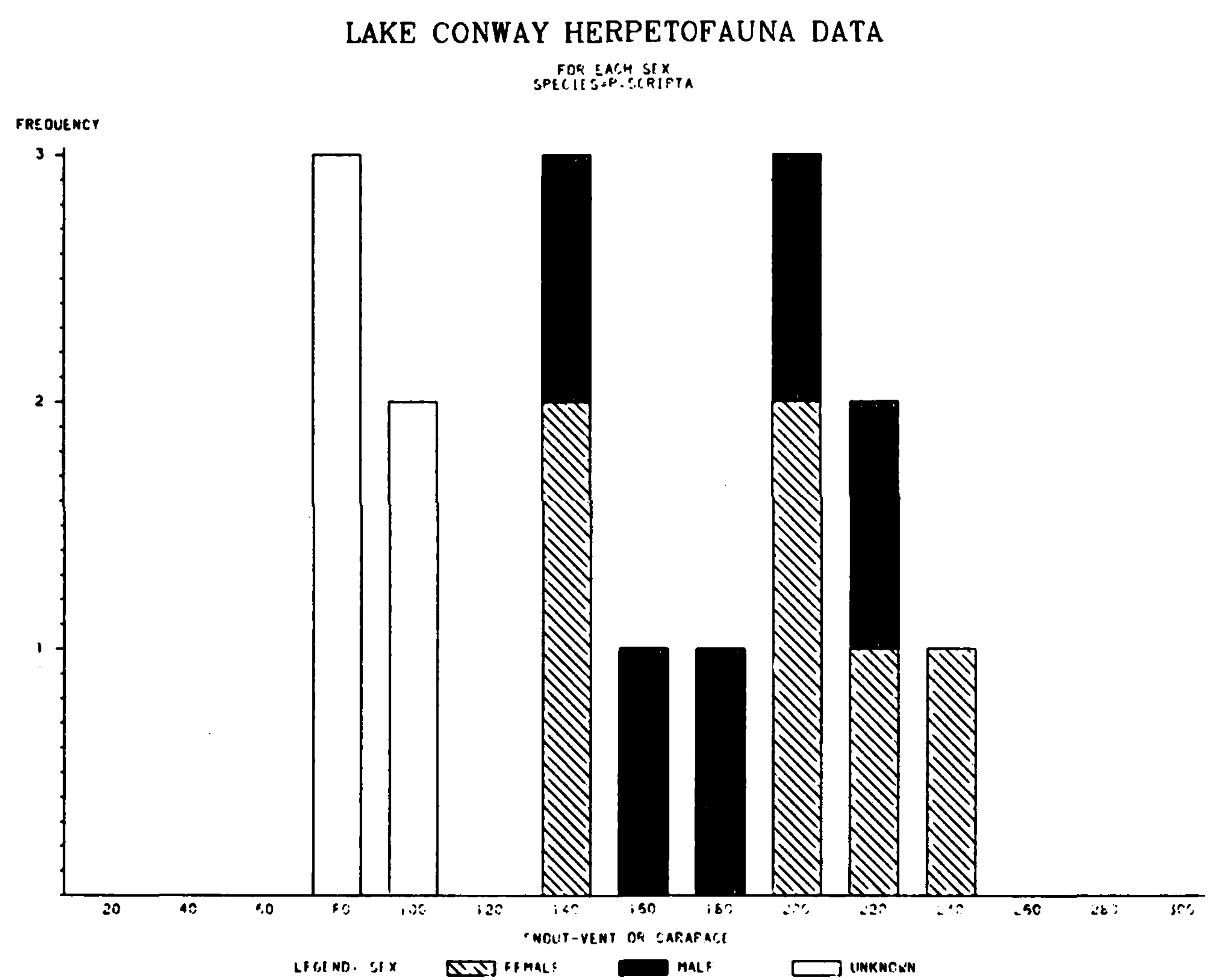

Figure 46. The size frequency distribution of Pseudemys scripta on Lake Conway.

scripta appears to suffer from the same mortality factors as other emydid turtles on Lake Conway. Two specimens were found with evidence of mammalian (river otter or raccoon) predation. Two others had boat propeller damage.

Food habits

258. The diet of Pseudemys scripta changes ontogenetically: juvenile are highly carnivorous, but as they mature, the amount of vegetable matter taken increases (Ernst and Barbour 1972).

Growth and Reproduction

259. Little is known about growth and reproduction of P. scripta on Lake Conway because of the small sample sizes. The several distinct size classes shown in Figure 46 suggest that a viable population is established on Lake Conway. Two adult females from East Pool were collected for study. One 244 mm. CL female taken on 26 August 1981 was post-reproductive with noticeable (1-2 mm.) corpora lutea. The other female (277 mm. CL) taken on 3 May 1982 contained 11 shelled eggs, 19 ova ranging in width from 22.5 to 27.5, and 13 smaller (17.2-21.6 mm.) ova. This latter female possibly would have produced three clutches in 1982. Growth and reproduction in native populations of P. scripta are known to vary geographically (Gibbons 1970, Moll and Legler 1971). In general, males mature earlier (at age 2-3 years) than females (4-8 years), and average smaller in body size. In southern populations females deposit several clutches of 2-19 eggs each year.

Kinosternon baurii (Striped mud turtle)

Distribution and Habitat Preferences

260. The striped mud turtle was the rarest kinosternid turtle on Lake Conway. Eleven individuals were marked during the study and three of these were recaptured (Table A2). In the first three years, most individuals (N=10) were observed or collected in South Pool, but the species also was taken in Middle Pool (1), and Gatlin Canal (3). Additional sampling in the fourth year detected its presence in East and West Pools. K. baurii was collected by several sampling methods including funnel traps (N=4), drift fence (3), herp-patrol (3), and shoreline census (3) (Table A1).

261. Other studies (Wygoda 1979, Dunson 1981, and references therein)

showed that K. baurii is most abundant in temporary pond habitats. In these situations the species typically undergoes terrestrial migrations when aquatic conditions become unfavorable. However, no detailed comparative studies of K. baurii on large permanent lakes such as Lake Conway are available. Most herpetofaunal sampling methods on Lake Conway were directed towards the aquatic environment and as a result terrestrial movements were rarely recorded. One female K. baurii captured 30 m. up on shore in a terrestrial drift fence in South Pool was recaptured 2 weeks later in the water. A male K. baurii was radiotelemetried along a developed section of South Pool for six months and a female K. baurii was radiotelemetried on the undeveloped East Pool islands for nine months. Both were recorded only in aquatic habitats during these times. These limited data suggest that terrestrial activity of K. baurii on Lake Conway may be uncommon compared to their behavior in more ephemeral environments.

262. On Lake Conway striped mud turtles were encountered in most major littoral zone habitats except white sand beaches where no individuals were sighted. Most specimens were observed in relatively shallow water (<0.5 m.). Only two K. baurii were seen in open water; all others were taken in the littoral zone or on shore.

Activity Patterns

263. Individuals of K. baurii were collected in January (1), April (2), June (3), July (3), September (1), and December (3), suggesting that the species is active year-round on Lake Conway.

Population Demography

264. Very little information concerning the population structure or density of K. baurii on Lake Conway was obtained. Most collected individuals were adults. Males ranged in size from 69 to 102 mm. CL (N=7) and females from 59 to 105 mm. CL (N=3). The relatively high proportion of recaptured individuals on permanent sites (three of eleven) and the low total number of sightings suggest that the population size is small. Because the species seems dependent upon an intact littoral zone, K. baurii probably is declining in abundance on Lake Conway.

Food Habits

265. Striped mud turtles are reported to be omnivorous (Ernst and Barbour

1972). The diet of Lake Conway specimens is unknown as none were taken for gut analysis.

Growth and Reproduction

266. The hinged shell of *K. baurii* prohibits palping for eggs and no information concerning reproduction was gathered for the Lake Conway population. In north Florida, females with oviducal eggs or fresh corpora lutea have been collected in every month of the year; clutch size is positively correlated with body size and ranges from one to five (Iverson 1979).

267. The only long-term recapture on Lake Conway was a female from Gatlin Canal which grew from 89 to 96 mm. CL and gained 41.7 g. in 14.2 months. She had five growth annuli when first captured and six when recaptured.

Kinosternon subrubrum (Eastern mud turtle)

Distribution and Habitat Preferences

268. Eastern mud turtles were relatively rare on Lake Conway, accounting for only 0.75% (N=90) of the total herpetofaunal observations and 1.86% of the 4,832 records for turtles (Table A2). Most individuals (53.33%) were collected on herp-patrols, but a proportion (33.33%) of *K. subrubrum* greater than any other species of turtle was taken in funnel traps (Table A1). *K. subrubrum* was the fourth most commonly collected turtle species on Lake Conway and had the most uneven distribution by pool: 63.3% (N=57) of the total sample was taken in South Pool and 78.9% (N=45) of these on the permanent site (Tables A2, A3). Fewer than a dozen were obtained in any other pool and the species was unknown from the East Pool permanent site (Table A3).

269. In spite of its rarity, *Kinosternon subrubrum* proved to be an ecologically interesting turtle. The species was confined to the vegetated littoral zone and the near-shore environment. No specimens were observed farther than 40 m. from shore and 95.74% of 47 herp-patrol animals was in water less than 1.6 m. deep; none was taken at a water depth greater than 2.5 m. Most (60.87%) individuals were over a sandy bottom. These general findings are supported by other studies. In over 1,800 captures of *K. subrubrum* inhabiting farm ponds in Alabama, none was collected farther than 5 m. from shore or in water deeper than 1 m. (Scott 1979).

270. Kinosternon subrubrum observed on herp-patrols showed a significant shift (X^2=20.93, P<.002) in habitat use during the study (Table 31). However, these data must be interpreted with caution because many of the cells have expected frequencies less than five; additional lumping would mask important trends. The cells contributing most to the chi-square were sightings over Vallisneria americana and "bare" habitats supporting no vegetation. In both of these habitats, fewer turtles than expected were seen in SY1, and more than expected in post-stocking years. Yearly deviations in littoral zone sightings and in Potamogeton illinoensis contributed little to chi-square. In general, these trends correspond to changes in shallow-water macrophyte populations observed on the lake (Schardt et al. 1981 and paragraphs 176-179 of this report), i.e., the coverage of V. americana and bare bottom increased while that of P. illinoensis decreased.

271. The relatively few K. subrubrum captured in funnel traps (N=29 for SY1-SY4) were not adequate for analysis of yearly trends but do provide an evaluation of habitat selection in the littoral zone. Three habitats, white sand beach, Nuphar luteum and Typha latifolia, yielded no captures in 1,976, 196, and 717 trap days, respectively. In order of increasing mean relative densities, the K. subrubrum capture rate per 100 trap days was 0.126 for Eichhornia crassipes (2 turtles/3,165 trap days), 0.162 for Panicum repens (1/617), 0.349 for bare bottom (2/573), 0.651 for Pontederia lanceolata (8/1,472), 0.840 for Panicum hemitomon (3/357), and 0.912 for Fuirena scirpoides (11/1,195). In this analysis "bare bottom" refers to trap stations that appear to be naturally void of vegetation as opposed to man-made white sand beaches. All bare bottom stations were within 5 m. of vegetated shoreline. When trap stations were scored by depth of the detrital layer independent of vegetation, mean K. subrubrum capture rates were 0.436 for sand bottom (0.920 if beach habitat was removed from analysis), 0.224, 0.285, 0.265, 0.0, and 0.0 for detrital layers 1-5 cm. deep, 6-10, 11-15, 16-20, and >20 cm., respectively.

272. The above analyses clearly suggest that on Lake Conway Kinosternon subrubrum prefers littoral zones with sandy bottoms that are dominated by the emergent plants Fuirena scirpoides, Panicum hemitomon, or Pontederia lanceolata. Interestingly, these habitat preferences are in marked contrast to

Table 31

Chi-square analysis of the yearly distribution of *Kinosternon subrubraum* on Lake Conway.

	Potamogeton illinoensis	Vallisneria americana	Bare bottom	Littoral zone	Total %
Study Year 1					
Observed	16	0	0	8	24
Expected	11.6	4.0	2.7	5.8	(44.44)
Chi-square	1.7	4.0	2.7	0.9	
Study Year 2					
Observed	5	2	3	1	12
Expected	5.8	2.0	1.3	2.9	(22.22)
Chi-square	0.0	0.0	2.1	1.2	
Study Year 4					
Observed	4	7	3	4	18
Expected	8.7	3.0	2.0	4.3	(33.33)
Chi-square	2.5	5.3	0.5	0.0	
Total	26	9	6		54
(%)	(48.15)	(16.67)	(11.11)		(100.00)

almost all other amphibian and reptile species regularly funnel-trapped on Lake Conway, which generally were most abundant at trap stations dominated by Eichhornia crassipes, Typha latifolia or P. lanceolata with deep detrital deposits.

273. Considering both the littoral zone and open water habitat preferences of this kinosternid turtle, the following generalization can be made. On Lake Conway relatively dense populations of K. subrubrum only occur along sections of sandy shoreline dominated by thin-stalked emergents. The adjacent open water environment must be shallow (<1.6 m.) with a thick cover of macrophytes, preferably Potamogeton illinoensis. Of the 90 K. subrubrum taken on Lake Conway, only four were observed more than 40 m. from a littoral zone fitting the above description.

Activity Patterns

274. Of the 27 Kinosternon subrubrum taken during dawn and dusk trap checks in SY1, 48.15% were captured during daylight hours; no seasonal trends in diel activity were apparent. The distribution of total captures varied by season ($\chi^2=31.86$, $P<.01$) with 14 taken in winter, 9 in spring, 44 in summer, and 23 in fall. Similar seasonal patterns were obtained for both funnel trap and herp-patrol results, suggesting that eastern mud turtles are most active in summer and fall.

275. Movement information based on recaptures was available for 12 of 52 marked animals. Most (83.3%) of these individuals were from South Pool. The time between recaptures ranged from 8 to 476 days ($\bar{X}=103.8$) and the distance moved from 0.0 m. to 132.0 m. ($\bar{X}=32.8$ m.). No apparent relationship existed between time and distance moved, thus K. subrubrum seemed to have small, restricted home ranges. Results of radiotelemetry work to be published elsewhere support this contention.

Population Demography

276. The size frequency distribution of the 83 Kinosternon subrubrum measured on Lake Conway is provided in Figure 47. The mean CL of 53 males (101.19 mm.) was significantly longer ($\chi^2=9.04$, $P=.0026$) than that of 29 females ($\bar{X}=93.76$ mm.). Most (75.0%) males were 100 mm. in CL or longer compared with only 37.8% of the females. Young animals were conspicuously absent from the sample. The sex ratio of the entire sample was biased towards

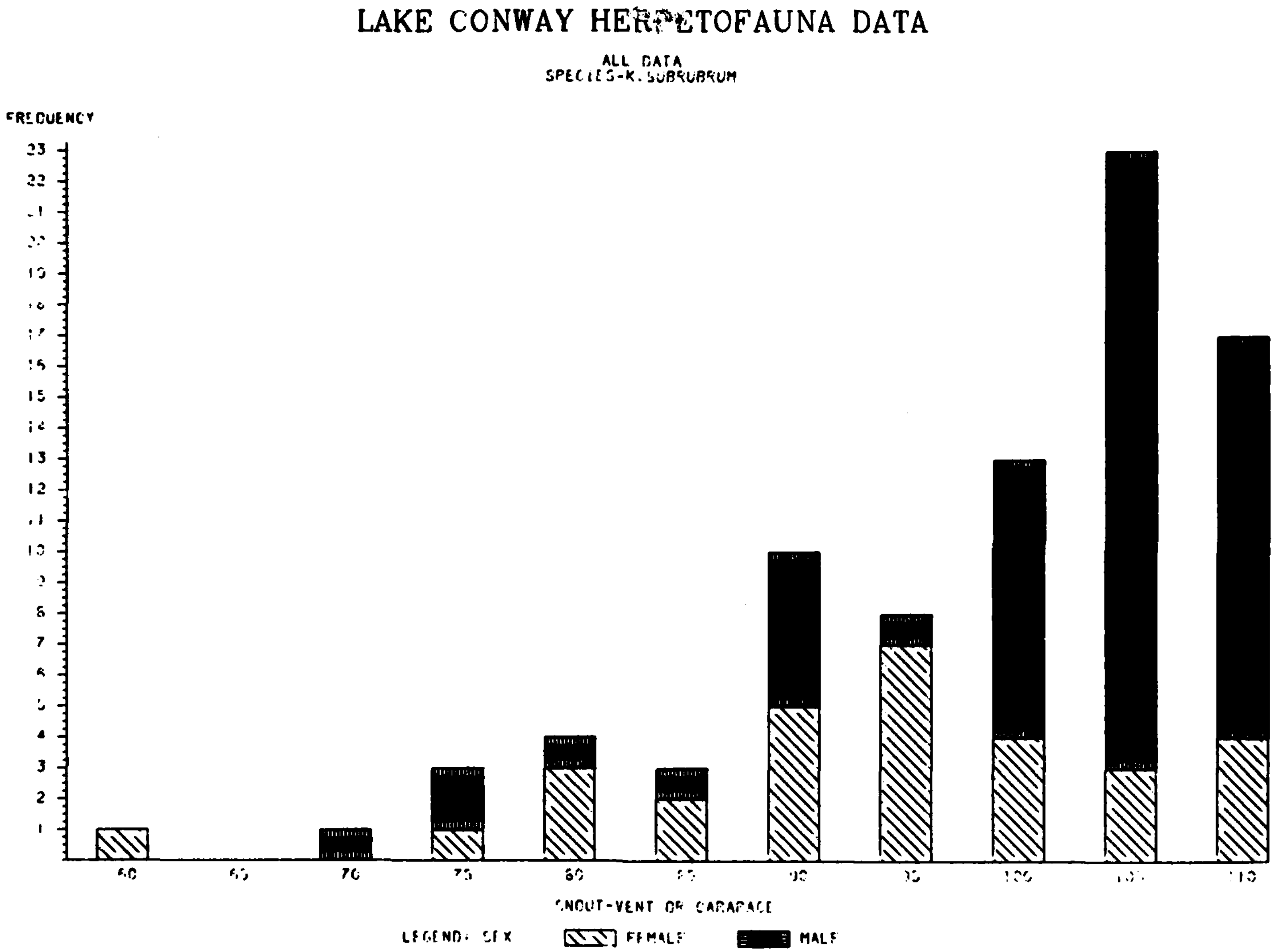

Figure 47. The size frequency distribution of Kinosternon subrubrum on Lake Conway.

males (1 female:1.83 males, X^2=7.02, P<.01); the same trend was obtained for both funnel-trapped (1 female:1.36 males) and herp-patrol (1 female:1.72 males) animals. No significant differences in mean CL among study sites or study years were detected (Kruskal-Wallis tests, P>.05).

277. The mean relative densities of K. subrubrum varied significantly among the permanent sites. Funnel-trap results (Table A4) were significant for both SY1 and all study years combined. In both cases mean densities were higher in South Pool than in all other pools which were not different from one another. The same trend was observed on herp-patrols (Table A5) but the Kruskal-Wallis sum-rank test used in the analysis did not detect any differences, presumably because of the large number of trips on which no K. subrubrum were observed.

278. Significant yearly changes in the relative density of funnel-trapped Kinosternon subrubrum were recorded for the South Pool site (X^2=54.025, P<.0001) and for all pools combined (X^2=61.47, P<.0001), the latter resulting largely from the density changes in South Pool (Table A4). No significant yearly differences in mean herp-patrol densities of this species were detected, but the number of individuals captured on herp-patrols decreased from 26 in SY1 to 12 in SY2 to 10 in SY3 (Table A1).

279. The variation in K. subrubrum densities, both among study sites and among study years, appears to be associated primarily with differences in habitat quality (see McDiarmid et al. 1983 for habitat descriptions). Among permanent sites South Pool was the only site with the proper combination of thin-stalked emergents and adjacent shallows dominated by Potamogeton illinoensis. The Middle Pool site had P. illinoensis offshore but only a small, 30 m. patch of Panicum hemitomon - Fuirena scirpoides; the rest of the shoreline supported a Typha latifolia marsh. Only two K. subrubrum were taken from this site, both from the panic grass - lake rush zone. On the East Pool site no K. subrubrum were taken and the habitat was of poor quality for this species, i.e., cattail and waterhyacinth associations with thick detrital deposits. The West Pool site had an outer fringe of P. hemitomon but the adjacent offshore supported mostly eelgrass beds and mud turtles were few. Almost all Gatlin Canal sightings of K. subrubrum were associated with Panicum repens, which lined much of the bank.

280. Following SY1, the densities of K. subrubrum on the South Pool site declined dramatically. These reductions were correlated with habitat destruction of the site for a housing development (McDiarmid et al. 1983), and were proportionately greater than those experienced by some other species. For example, the total catch of the other common kinosternid Sternotherus odoratus declined 66.4% (from 336 individuals to 113) but the abundance of K. subrubrum in SY1 was reduced 89.5% by SY2 and 92.1% by SY3 (from 38 to 4 to 3) (Table A3). Presumably the duel dependence of K. subrubrum on specific open water and littoral zone habitats caused its higher rate of extirpation on this site. In addition, no evidence exists to suggest that K. subrubrum moved off this site to other habitats in South Pool since, unlike stinkpots, (1) no mud turtles were ever recaptured off the site, and (2) no other habitat suitable for K. subrubrum occurred in the pool, e.g., whereas 63.7% of the total S. odoratus sample from South Pool was taken off the permanent site on the extended herp-patrols (Fig. 1, Tables A2, A3), only 21.1% (N=12) of the K. subrubrum were taken off the site and five of these were recaptured. We believe that most of the mud turtles originally inhabiting the South Pool site either were killed during construction activities, died as an indirect result of habitat depletion, or emigrated overland.

Food Habits

281. Only five Kinosternon subrubrum from Lake Conway were available for dietary study. One individual had an empty stomach, the other four contained 59 individual prey weighing a total of 3.17 g. (Table 32). Crayfish, aquatic insects and mollusks were important components of the diet; we suspect that the fish eggs found in one individual were fortuitous. Mahmoud (1968) reported the following percentages of frequency and volume respectively of food items for K. subrubrum from Oklahoma: Insecta 98.3, 30.4; Crustacea 15.0, 1.4; Mollusca 93.1, 31.8; Amphibia 30.0, 2.2; carrion 68.6, 11.9; and aquatic vegetation 89.6, 22.3.

Growth and Reproduction

282. The size frequency distribution given in Fig. 47 shows that most of the Kinosternon subrubrum captured on Lake Conway were adults. Seventeen individuals (all adults) were recaptured and eight of these were taken more than 100 days apart. Three of these latter individuals showed no growth

Table 32

Habitat analysis of the yearly distribution of *Sternotherus odoratus* on Lake Conway.

	Nitella megacarpa	*Potamogeton illinoensis*	*Vallisneria americana*	Bare bottom	Littoral zone	Total (%)
Study Year 1						
Observed	0	152	22	37	150	361
Expected	5.7	147.1	75.8	58.4	72.7	(15.83)
Chi-square	5.7	0.2	38.2	10.2	82.3	
Study Year 2						
Observed	11	565	180	191	183	1130
Expected	17.8	460.4	237.4	182.9	227.5	(49.56)
Chi-square	2.6	23.8	13.9	0.5	8.7	
Study Year 3						
Observed	25	212	277	149	126	789
Expected	12.5	321.5	165.8	127.7	158.8	(34.61)
Chi-square	12.6	37.3	74.7	2.9	6.8	
Total (%)	36 (1.58)	929 (40.75)	479 (21.01)	377 (16.54)	459 (20.13)	2280 (100.00)

including one 103 mm. CL male with captures 476 days apart. A 101 mm. CL male captured 715 days later had grown only 2 mm. (1.53 mm./yr.). The mean growth rate per year was 1.71 mm. CL for two females and 2.27 mm. CL for six males.

283. Ernst et al. (1973) summarized information on growth of Kinosternon subrubrum in Florida. Hatchlings averaged 17.8 mm. in plastron length (=PL). Females apparently reached maturity at age 6-8 yr. at 66-75 mm. PL while males matured in 4-5 yr. at 53-60 mm. PL. In Florida the species may nest throughout the year and clutch size ranged from 2 to 5 eggs (Iverson 1977).

Sternotherus odoratus (Stinkpot)

Distribution and Habitat Preferences

284. More is known about the biology of stinkpot turtles than any other herpetofaunal species on Lake Conway. With 3,523 total observations (Table A2), stinkpots were numerically dominant, accounting for 29.54% of the total herpetofaunal records and 72.91% of the sample for turtles. Most (44.25%) individuals were recorded from South Pool followed by Middle (20.78%), West (15.07%), Gatlin (12.29%), and East (7.61%). Sternotherus odoratus also made up 20.01% of the total permanent site observations; 44.05% of the sample for this species was taken on these sites (Tables A2, A3). Herp-patrols were the most productive sampling method, yielding 92.26% of the stinkpot catch.

285. The large number of Sternotherus odoratus with complete habitat information (N=2,280) permits an extensive analysis. Table 33 summarizes the yearly distribution of these individuals by the dominant plant species or habitat type. On Lake Conway most stinkpots observed on herp-patrols were over Potamogeton illinoensis (40.75%), followed by Vallisneria americana (21.01%), and littoral zone plant species (20.13%). Highly significant (χ^2=330.58, P<.0001) yearly shifts in habitat use were detected. Important yearly trends were a reduction in the use of the littoral zone and Potamogeton illinoensis and an increase in the use of Vallisneria americana, Nitella megacarpa, and bare bottom habitats (Table 33). These general observations are concordant with pool-wide changes in macrophyte (Schardt et al. 1981) and littoral zone (Williams et al. 1982) plant communities as a result of selective grazing by white amur and shoreline development.

Table 33

Habitat analysis of the yearly distribution of *Sternotherus odoratus* on South Pool.

	Nitella megacarpa	*Potamogeton illinoensis*	*Vallisneria americana*	Bare bottom	Littoral zone	Total (%)
Study Year 1						
Observed	0	98	12	13	26	149
Expected	4.6	79.3	17.5	26.7	20.4	(12.86)
Chi-square	4.6	4.4	1.7	7.1	1.5	
Study Year 2						
Observed	11	377	58	83	73	602
Expected	18.7	320.5	70.6	108.0	82.6	(51.94)
Chi-square	3.2	10.0	2.3	6.3	1.1	
Study Year 3						
Observed	25	142	66	115	60	408
Expected	12.7	217.2	47.9	73.2	56.0	(35.20)
Chi-square	12.0	26.0	6.9	21.6	0.3	
Total (%)	36 (3.11)	617 (53.24)	136 (11.73)	211 (18.21)	159 (13.72)	1159 (100.00)

286. Table 33 indicates that 20.13% of all the stinkpots observed on herp-patrols were found in the littoral zone, and that this proportion decreased during the study. Summed over all study years and pools the percentage of littoral zone animals (N=459) by plant species was: 34.3% (Panicum hemitomon), 27.2% (Nuphar luteum), 20.9% (Typha latifolia), 8.4% (Nymphaea odorata), 9.2% (Panicum repens, Eichhornia crassipes, Fuirena scirpoides, Pontederia lanceolata). These values should not be construed as habitat preferences within the littoral zone since sampling effort varied with plant species. However, the results do indicate that S. odoratus frequented all of the common littoral zone plant species present on Lake Conway.

287. Schardt et al. (1981: Fig. J6-J10) showed that the response of macrophyte communities to white amur varied with pool. Our herp-patrol effort for Sternotherus odoratus (including permanent, selective and extended site herp-patrols, and kill sampling) was adequate in terms of sample size and percent of pool sampled to evaluate pool-wide trends in South, East and West Pool. The large size of Middle Pool prohibited extensive survey work in this pool. Most of the sample from Lake Gatlin was obtained in Gatlin Canal, which was not representative of the entire pool (Tables A2, A3).

288. The entire perimeter of South Pool was herp-patrolled (Fig. 1) and our knowledge of habitat preferences of S. odoratus is most complete for this pool. In addition, South Pool experienced the greatest vegetative change of any pool: a reduction from 66% to 39% in total macrophyte coverage (Schardt et al. 1981: Fig. J6). Table 33 shows that the occurrence of stinkpots over specific habitats changed with study year on this pool (X^2=110.33, P<.0001). Potamogeton illinoensis was the most abundant shallow-water macrophyte in South Pool (Schardt et al. 1981). Stinkpot sightings over this plant decreased from 65.8% of the total in SY1 to 62.6% in SY2 to 34.8% in SY3. The large reduction in turtle sightings over P. illinoensis from SY2 to SY3 corresponds exactly with temporal changes in the mean percent frequency of this species on the pool; from 21.8% in SY1 and 20.9% in SY2 to 3.7% in SY3 (Schardt et al. 1981: Fig. D4; Tables B6, B11, B16). Similar yearly correspondences in S. odoratus sightings (Table 33) and habitat availability did not occur for the plants Vallisneria americana or Nitella megacarpa (Schardt et al. 1981: Fig. D5 and D3, respectively): turtle sightings over both of these plant species were

proportionately higher than expected only in SY3. Our interpretation is that P. illinoensis was the preferred habitat of stinkpots in this pool. As white amur substantially reduced this plant species between SY2 and SY3, compensatory shifts to other, less preferred macrophyte species or to bare bottom habitats occurred. These shifts in plant availability and usage patterns also influenced the mean water depths at which S. odoratus foraged: from 0.83 m. in SY1 to 1.17 m. in SY2 to 1.24 m. in SY3. Importantly, human destruction of littoral zone habitat in this pool (McDiarmid et al. 1983: paragraphs 24-25) seems not to have influenced open water habitat selection by S. odoratus. The percentage of stinkpots in the littoral zone changed little from year to year (17.45% in Sy1, 12.13% in SY2, 14.71% in SY3) and the littoral zone category contributed only 2.63% to the total chi-square. We infer that the observed significant yearly changes in habitat of this turtle species in South Pool were the direct result of white amur.

289. In East Pool, significant yearly shifts in habitat use by Sternotherus odoratus also were detected (X^2=47.31, P<.0001). Trends were similar to those in South Pool. As the percent coverage of Potamogeton illinoensis decreased from 37% in 1977 to 7% in 1980 and Vallisneria americana increased from 15% to 40% (Schardt et al. 1981: Fig. J9, J10), stinkpots shifted to eelgrass habitats. This change especially was noticeable around the East Pool islands where P. illinoensis almost was eliminated. Although not covered specifically in this report, during 1981 extensive grazing by white amur removed a large eelgrass bed (centered at coordinates 415, 520) in a period of about four months. Historically, this V. americana bed supported a dense stinkpot population often with 50 animals seen in less than 1 hr. Removal of this bed resulted in the almost complete disappearance of S. odoratus from the area, and provided the most dramatic example of the potential effects of white amur on the habitat of this turtle.

290. Extensive herp-patrol work in West Pool (Fig. 1) also demonstrated temporal changes in habitat use by S. odoratus (X^2=156.53, P<.0001). Again, a reduction in Potamogeton illinoensis habitat caused animals to shift to Vallisneria americana, which increased in coverage from 9% in SY1 to 17% by SY3 (Schardt et al. 1981: Fig. J9, J10). On the extended herp-patrol section of West Pool (Fig. 1) we observed the near elimination of several P. illinoensis

beds by white amur. In each case removal of these beds was followed by a gradual reduction in the number of turtles seen at the site.

291. Table 34 shows that male and female Sternotherus odoratus responded differentially to changes in habitat on Lake Conway (χ^2=11.65, P=.02). The expected number of individuals of each sex was similar to the observed number for Nitella megacarpa, Potamogeton illinoensis, Vallisneria americana, and the littoral zone category, but not for bare bottom habitat which accounted for 80.69% of the total chi-square. Although less than 10% of the sample for each sex was found over bare bottom, males seemed to avoid this habitat to a greater extent than did females, and this factor alone produced the significant chi-square. In each study year proportionately fewer males than females were encountered over bare bottom but sexual differences became more pronounced as this habitat increased in abundance on the lake system. During baseline conditions, 14.42% more females than males were seen over bare bottom; this percentage difference increased to 29.76% in post-stocking years.

292. In summary Sternotherus odoratus was a common inhabitant of the shallow, vegetated waters of Lake Conway. As selective grazing by white amur removed most of the near-shore Potamogeton illinoensis beds, stinkpots shifted to alternate habitats, especially Vallisneria americana and bare bottom. Males avoided bare bottom to a greater degree than females. Destruction of the littoral zone had little affect on stinkpot habitat selection: white amur was of overwhelming importance.

Activity Patterns

293. Stinkpots were active both during the day and night on Lake Conway. Of 27 S. odoratus captured in funnel traps in the first year, 70.37% were taken during darkness, suggesting that this turtle is chiefly nocturnal. The mean monthly relative densities of stinkpots on herp-patrols are given in Figure 48. The grand mean was 4.07 individuals per hour. Two general peaks are apparent, one in March ($\bar{X}$=6.11/hr.) and another in October ($\bar{X}$=6.21/hr.) and November ($\bar{X}$=7.58/hr.). The lowest number of individuals typically was observed in summer. Seasonal means summed over all sites and study years supported this contention: winter = 4.41 S. odoratus/hr., spring=3.80/hr., summer=2.77/hr., fall=5.57/hr.

294. Figure 49 shows that the relative seasonal abundance of S. odoratus

Table 34

Habitat analysis of male and female *Sternotherus odoratus* on Lake Conway.

	Nitella megacarpa	*Potamogeton illinoensis*	*Vallisneria americana*	Bare bottom	Littoral zone	Total (%)
Males						
Observed	19	455	240	154	210	1078
Expected	17.5	442.7	234.9	182.5	200.5	(52.89)
Chi-square	0.1	0.3	0.1	4.4	0.5	
Females						
Observed	14	382	204	191	169	960
Expected	15.5	394.3	209.1	162.5	178.5	(47.11)
Chi-square	0.2	0.4	0.1	5.0	0.5	
Total (%)	33 (1.62)	837 (41.07)	444 (21.79)	345 (16.93)	379 (18.60)	2038 (100.00)

LAKE CONWAY HERPATROL RESULTS FOR EACH MONTH

FIRST THREE YEARS INCLUDED
SPECIES=S ODORATUS

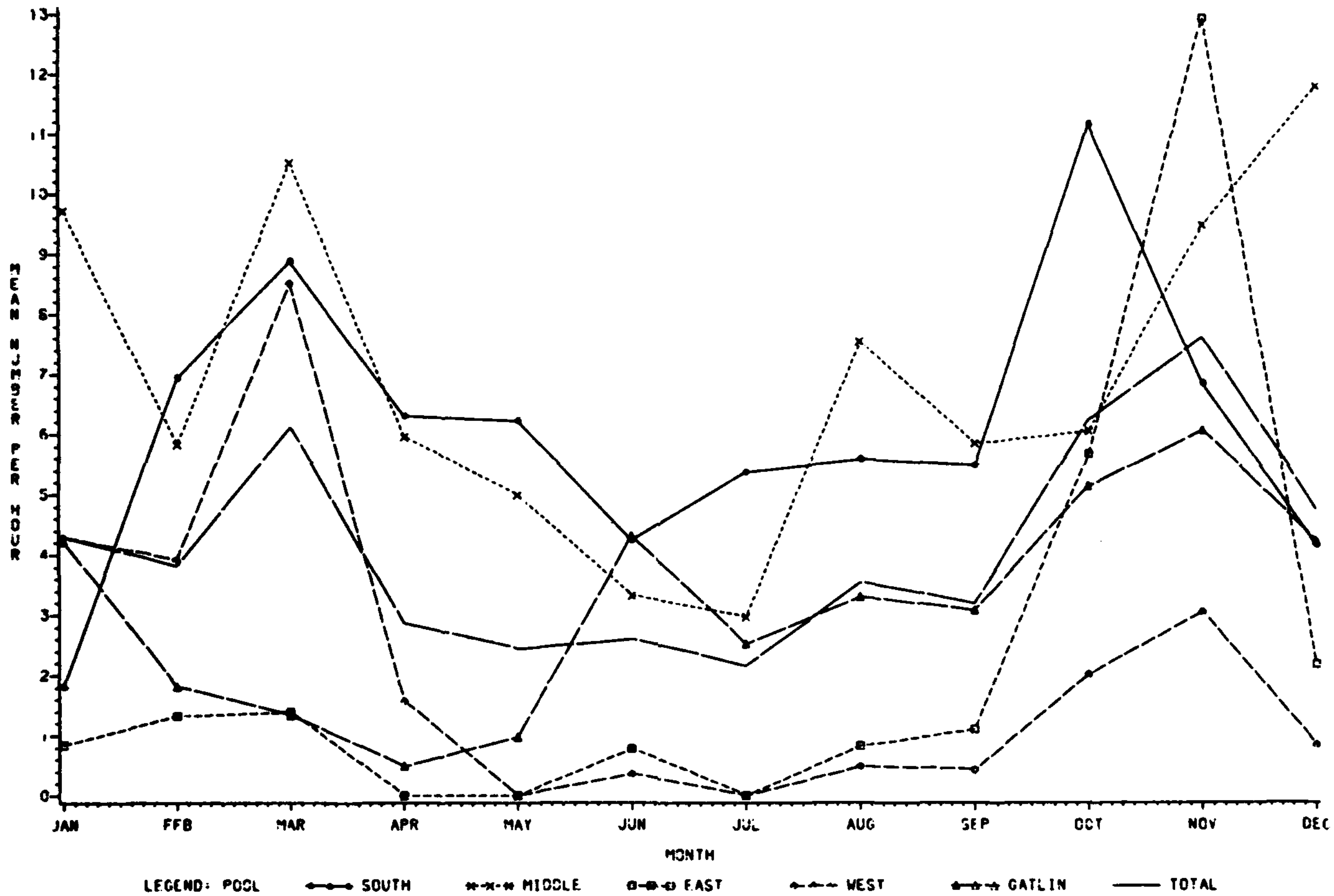

Figure 48. The mean number of Sternotherus odoratus sighted per hour in each month on the permanent sites during the three-year study.

LAKE CONWAY HERPATROL RESULTS FOR EACH SEASON

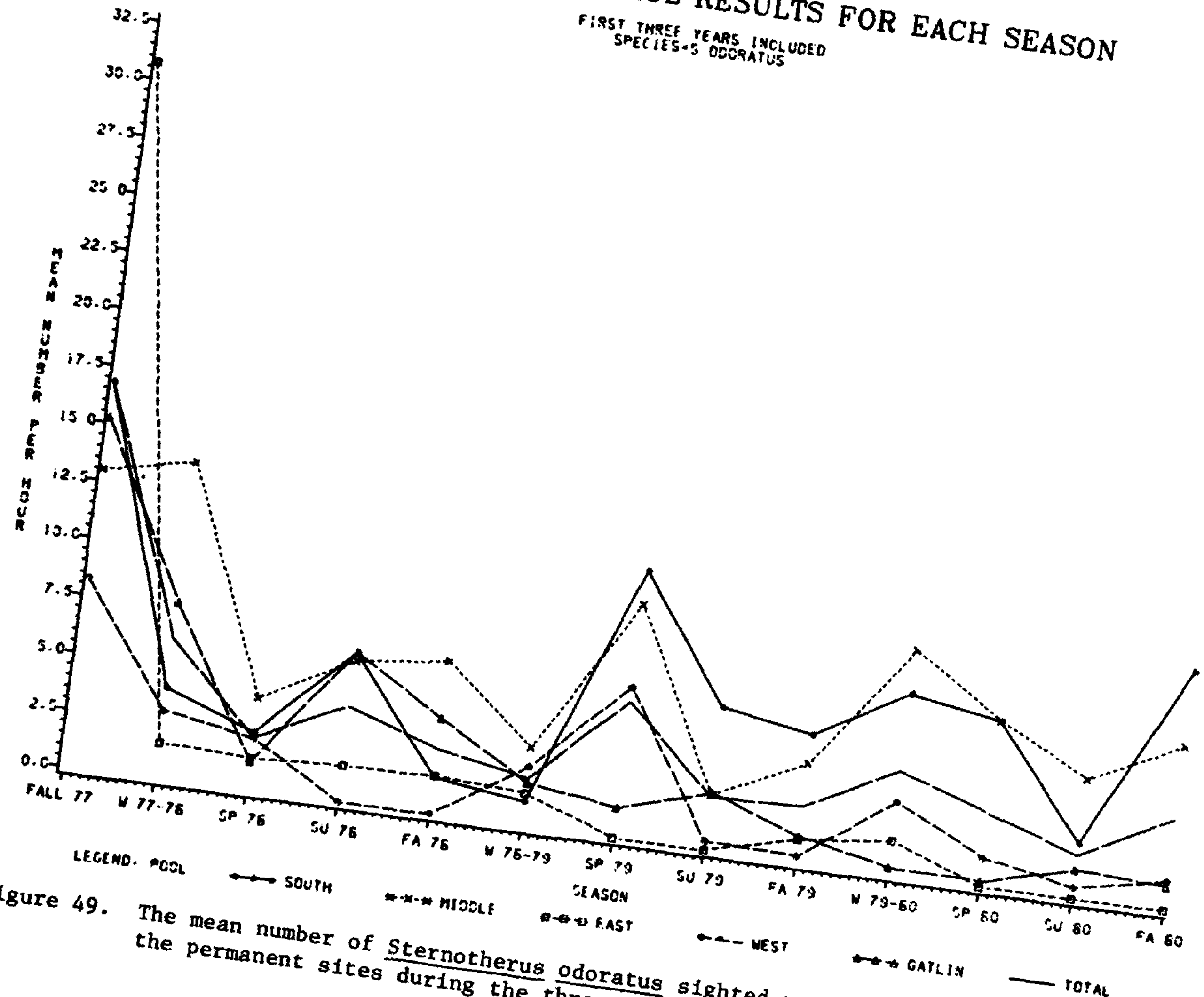

Figure 49. The mean number of Sternotherus odoratus sighted per hour in each season on the permanent sites during the three-year study.

varied with study year. Most of the October-November peak in Figure 48 was caused by high relative densities during the fall of 1977 (Fig. 49). This fall peak was not observed in other years; instead mean densities were highest in the summer of 1978, the spring of 1979, and the winter of 1980 (Fig. 49). These yearly fluctuations in the peak mean seasonal density of stinkpots on the permanent sites largely were the result of prevailing weather conditions. High, sustained winds severely hampered our ability to see turtles, and these conditions changed each year. The general pattern of high densities in the fall of 1977 followed by low to moderate densities for the remainder of the study is related to the population dynamics of this species on the permanent sites (see paragraphs 308-311).

295. Movement information based on recaptures was available for 369 of the 2,291 S. odoratus marked on Lake Conway. Fourteen (3.7%) of these animals (five females, nine males) were recaptured in a pool different from where they were marked originally, including movements from South to Middle (N=1), Middle to South (1), Middle to East (1), Gatlin Canal to West (8), and West to Gatlin Canal (3). Because of the large number of stinkpots marked we suspect that some of these latter individuals may have been released accidentally in the wrong pool (e.g., Middle to East Pool).

296. For stinkpots that remained in the same pool, time between captures accounted for a significant ($F=47.78$, $P<.0001$) amount of the variation in linear distance moved ($r^2=0.119$, Fig. 50). Although no differences were detected ($F=0.68$, $P=.41$) between males ($\bar{X}$ distance = 230.5 m., N=160) and females ($\bar{X}=209.3$ m., N=196), significant variation in linear distance moved was found among the pools ($F=5.05$, $P=.0006$). In general the mean distance between captures in each pool (South = 274.5 m., Middle = 76.9 m., East = 127.6 m., West = 133.4 m., Gatlin = 160.0 m.,) was positively correlated with the size of the herp-patrol transects in each pool (Fig. 1). Thus, we believe that the measured between-pool differences in movements were artifacts of our sampling program, and did not indicate actual differences in activity. Similarily, a significant increase in mean distance moved between captures was detected ($F=6.65$, $P=.0104$) for S. odoratus marked during the first ($\bar{X}=255.1$ m.) and second halves ($\bar{X}=375.2$ m.) of the study. Although an increase in movement and home range size would be expected as white amur reduced the size and

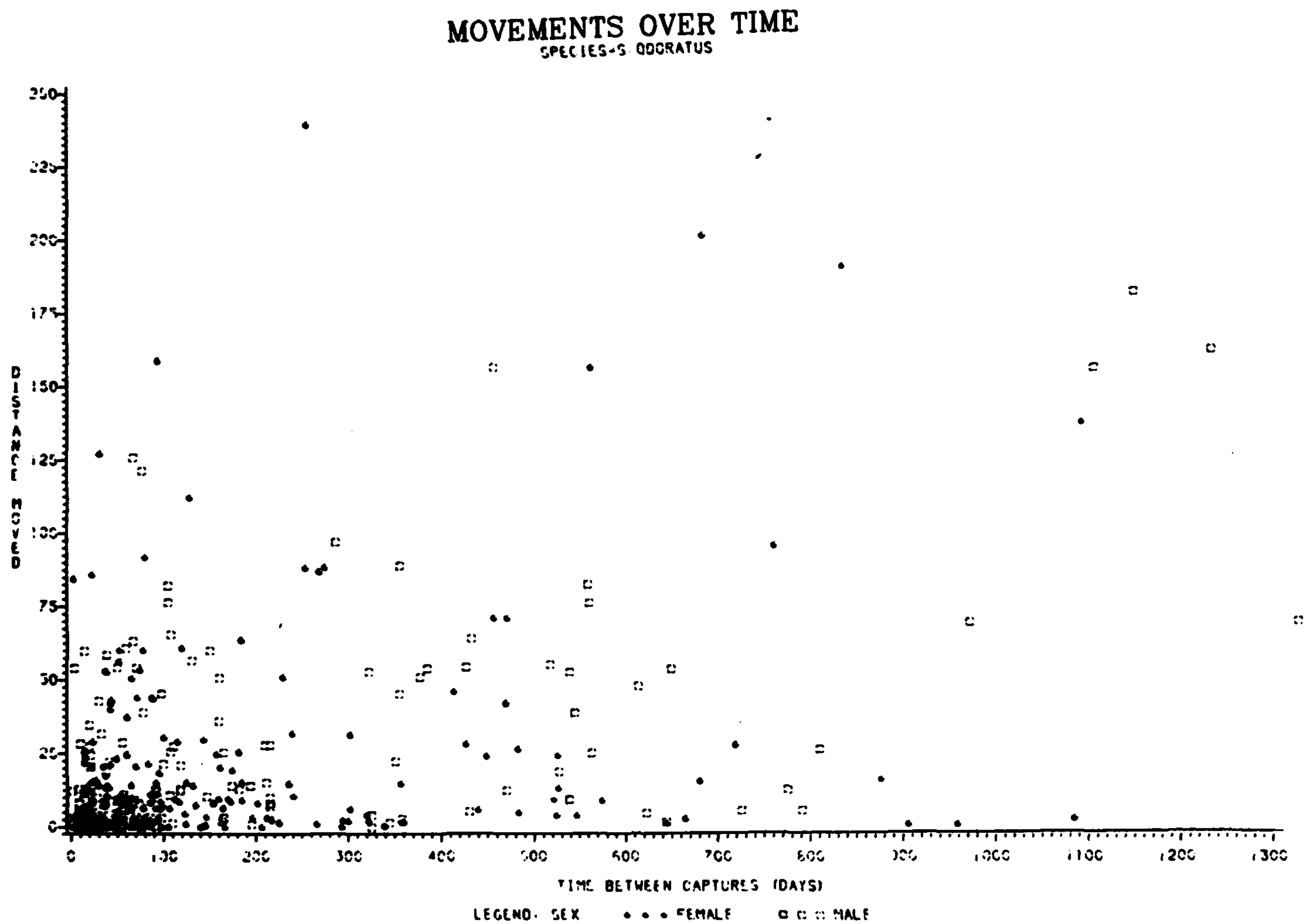

Figure 50. Relationship between time between captures and linear distance moved in Sternotherus odoratus.

suitability of habitat, this potential effect was confounded by temporal increases in the sizes of the herp-patrol transects (see McDiarmid et al. 1982 for details).

Population Demography

297. Stinkpots were the most abundant turtle species on Lake Conway (Table A2); accordingly, much is known about their population dynamics and demography. In this species sexual dimorphism was evident prior to maturity, and even very small individuals often could be sexed. Males had elongated and thickened tails which typically terminated in a blunt nail; females had short tails that lacked a terminal nail (Gross 1982).

298. For the entire sample of Sternotherus odoratus (N=3,008) for which sex could be determined, the observed sex ratio (1 female to 1.16 males) differed significantly from 1:1 (χ^2=16.68, P<.001). However, no differences in this mean sex ratio were detected among pools (χ^2=1.93, P>.74) or among study years (χ^2=2.69, P>.26). Separate sex-ratio analyses conducted for each month and for each sampling trip showed significant differences in less than 5% of the tests; such results would be expected if no differences existed. The slight bias in favor of males could be due to differences in activity and consequent susceptibility to detection and capture. Previous recapture analyses showed that males moved slightly greater distances between captures than females. Thus, males may have moved off our permanent sites and avoided recapture more often than females. In fact, the percentage of marked individuals that were recaptured was lower for males (17.20%) than for females (20.92%), although the difference was not significant (χ^2=3.45, P>.05). For these reasons we suspect that the true sex ratio of S. odoratus on Lake Conway was not different from 1:1.

299. The size frequency distribution of all stinkpots captured on Lake Conway is given in Figure 5.. Sexual size dimorphism is apparent. The mean carapace length of 1,389 females was 67.00 mm. (mode=69 mm. CL) compared to 59.96 mm. for 1,606 males (mode=61 mm. CL). The five longest females were 87 to 92 mm. CL and the five longest males 79 to 83 mm. CL. In addition, the distributions of the sexes were different. Although females were skewed to the left of the mean with a noticeable central tendency (kurtosis=-1.21), males showed only slight skewness and a more flattened distribution (kurtosis=-0.51).

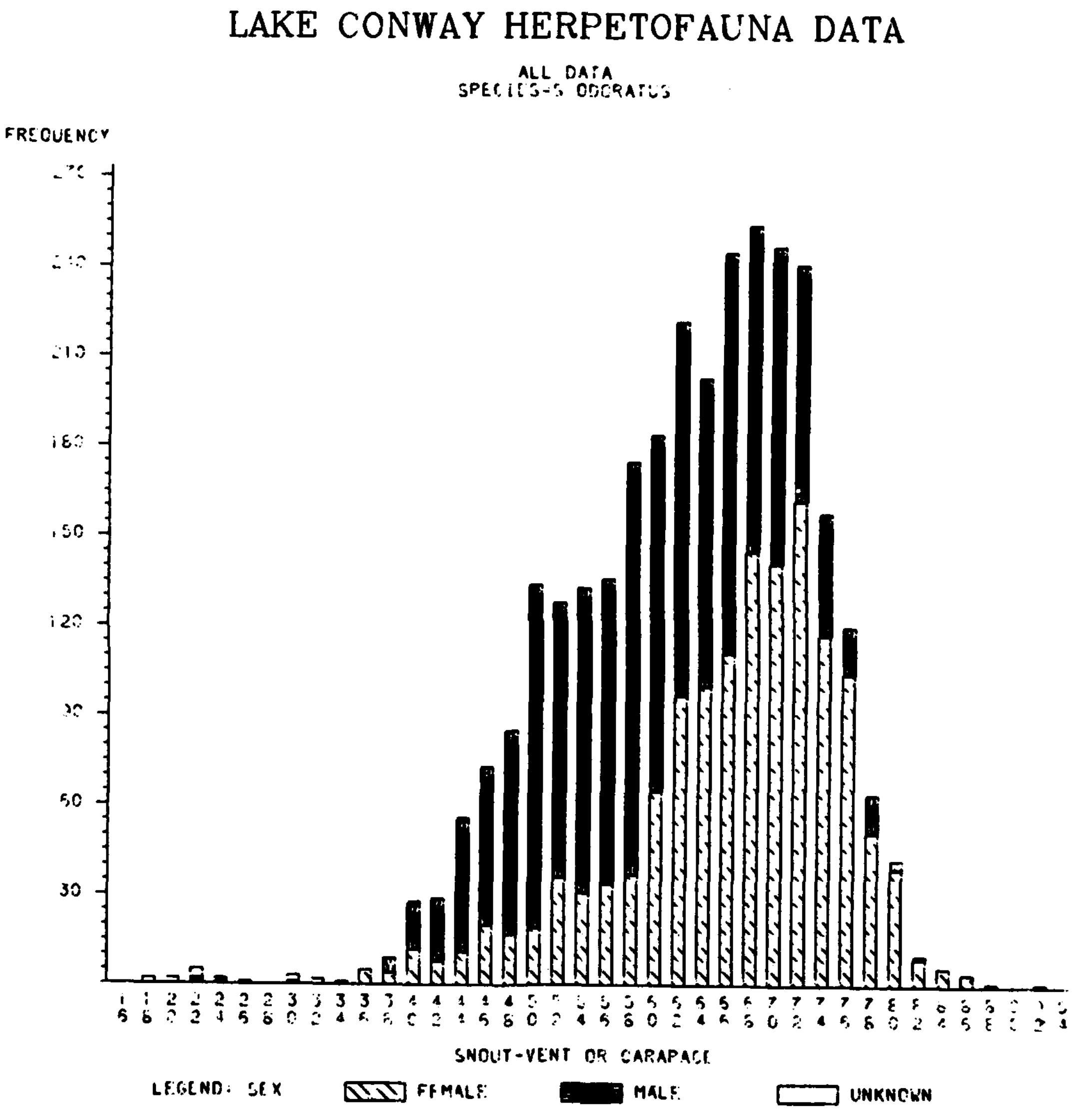

Figure 51. The size frequency distribution on Sternotherus odoratus on Lake Conway.

300. In the Lake Conway population, male Sternotherus odoratus matured at an average size of 50 mm. CL compared with 60 mm. CL for females (see Growth and Reproduction section for details). On this basis at least 13.0% of the sampled male population and 17.0% of the females probably were immature (Fig. 51). Very small (<40 mm. CL) juveniles were poorly represented and comprised only 1.1% of the sample. We suspect that to some unknown degree the low relative abundance of smaller size classes was the result of sampling bias.

301. Most (92.26%) stinkpots were collected on herp-patrols (Table A2) which tended to sample animals occurring in deeper, open water habitats. The mean size of 53 S. odoratus collected in littoral zone funnel traps (55.1 mm. CL) was significantly smaller (χ^2=6.35 P=.0117) than the mean (61.9 mm. CL) for 1,838 individuals taken on herp-patrols. Juvenile S. odoratus probably spend most of their time in shallow (<10 cm.), densely vegetated littoral zones where predation pressure presumably was lower and food availability higher. As a result of this bias, juveniles were under-represented in our samples. However, because sampling methods were consistent between pools and between study years, we believe that any detected variation in size structure represents actual differences among the populations.

302. Tables 35 and 36 provide pool and yearly comparisons of the mean carapace length of male and female Sternotherus odoratus from Lake Conway. For both sexes body size averaged smaller in Gatlin and Middle; in other pools individuals were similar in size but larger. This trend was consistent in all pool-wise comparisons with significant results. Significant yearly differences in carapace length also were detected for males (South Pool and species mean; Table 35) and females (South and Middle Pool, and species mean; Table 36). In all significant comparisons both sexes increased in mean body size from pre- to post-stocking periods. The greatest mean difference in carapace lengths among study years summed over all pools for both females (4.42%, SY1 versus SY3) and males (4.82%, SY1 versus SY3) was less than the difference in carapace length among pools summed over all study years for females (7.50%, Gatlin versus East) and for males (7.13%, Middle versus East or West).

303. The differences in Sternotherus odoratus mean body size among pools and among study years most likely have an ecological basis. The concordance of results between the sexes suggest that the factor(s) responsible for the

Table 35

Mean carapace length in mm. of male *Sternotherus odoratus* at Lake Conway. Yearly and pool comparisons on the chi-square approximation of the Kruskal-Wallis test (KW). (* = P<.05, ** = P<.01, NS = not significant). If significant between-year or between-pool differences were detected (P<.05), pair-wise comparisons were performed. Means with the same letter to the right of a value indicate no significant difference between those pools (P<.025); letters to the left of a value indicate no significant difference between those years (P<.025). See text for details.

	South Pool	Middle Pool	East Pool	West Pool	Gatlin Canal	Species Mean	KW
Study Year 1 (Sample Size)	A 59.6 (189) AB	57.0 (215)	61.4 (44) A	59.4 (28) AB	58.0 (184) B	58.4 (660)	13.48**
Study Year 2 (Sample Size)	B 61.8 (308) A	57.3 (86)	62.2 (32) A	61.8 (121) A	56.6 (18) A	A 61.0 (565)	18.72**
Study Year 3 (Sample Size)	AB 61.4 (183) AB	58.5 (53) B	61.6 (50) AB	62.4 (88) A	54.3 (7) AB	A 61.1 (381)	11.14**
Mean for Years (Sample Size)	61.1 (680) A	57.3 (354) B	61.7 (126) A	61.7 (237) A	57.8 (209) B	60.0 (1606)	67.25**
KW	7.00*	1.61ns	0.20ns	2.76ns	1.20ns	35.21**	

Table 36

Mean carapace length in mm. of female *Sternotherus odoratus* at Lake Conway. Yearly and pool comparisons were based on the chi-square approximation of the Kruskal-Wallis test (KW). (* = P<.05, ** = P<.01, NS = not significant). If significant between-year or between-pool differences were detected (P<.05), pair-wise comparisons were performed. Means with the same letter to the right of a value indicate no significant difference between those pools (P<.025); letters to the left of a value indicate no significant difference between those years (P<.025). See text for details.

	South Pool	Middle Pool	East Pool	West Pool	Gatlin Canal	Species Mean	KW
Study Year 1 (Sample Size)	65.2 (177) A	A 64.9 (180) A	70.2 (31)	65.1 (19)	64.5 (134) A	65.2 (541)	13.03*
Study Year 2 (Sample Size)	A 68.8 (245) A	A 65.5 (97) B	69.8 (31) AB	68.1 (138) AB	65.6 (18) AB	A 68.0 (529)	10.67*
Study Year 3 (Sample Size)	A 69.1 (169)	69.2 (45)	68.4 (45)	68.0 (53)	53.6 (7)	A 68.5 (319)	4.51ns
Mean for Years (Sample Size)	67.8 (591) A	65.7 (322) C	69.3 (107) B	67.8 (210) AB	64.1 (159) C	67.0 (1389)	41.97**
KW	19.44**	11.33**	0.23ns	2.01ns	2.79ns	45.40**	

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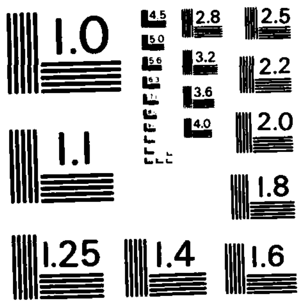

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demographic differences affect both sexes similarly. The percent differences in carapace length for both sexes was greater among pools than among study years. However, this does not necessarily mean that the variation among pools was greater than that among years because the sources of variation were different. The relatively low detected rates of interpool movements (see paragraph 295) and the long lifespan of S. odoratus suggest that distinct, rather sedentary populations occupy each pool. Thus, variation among pools reflect differences among populations whereas variation among years reflect changes within the same population.

304. We suspect that the observed differences in S. odoratus carapace length among pools were caused by subtle differences in habitat quality which indirectly affected growth rates, survivorship, density, or other demographic parameters. The relationship is apparently complex. For example, by using analysis of covariance to adjust body size to a common carapace length (see paragraph 51 for procedure and rationale) significant differences in the relative body mass of stinkpots among the pools was detected for male ($F=4.27$, $P=.0019$) and for female stinkpots ($F=2.60$, $P=.0347$). Assuming that variation in food availability and hence growth rates between pools was responsible for differences in both relative body mass and mean carapace length, then concordance between the two is expected. This condition was realized in females whose adjusted least squares mean body mass in each pool (Gatlin=47.13 g., Middle=47.53 g., South=47.77 g., West=48.03 g., East=48.88 g.) was in rank-order agreement with mean carapace lengths (Table 37). However, for males the relative positions of Middle and West Pools were reversed (adjusted least squares mean body mass: Gatlin=30.52 g., West=30.59 g., South=30.77 g., Middle=31.17 g., East = 31.60 g.) compared with their average carapace lengths in these pools (Table 36). The cause(s) of this shift in rank-order is unknown but the results suggest that factors other than food availability and growth rates affect the eventual body size of male S. odoratus in these pools.

305. An explanation of yearly differences in the mean carapace lengths of stinkpots (Tables 35 and 36) requires an understanding of the potential effects of mark-recapture procedures on survival. Most turtle species (e.g., emydids) on Lake Conway were marked throughout the study by drilling holes in the marginal scutes (Cagle 1939), a procedure which had no apparent effect on

survivorship. However, stinkpots have fewer marginals than emydids and a different marking system was used. From July 1977 through December 1977, S. odoratus were toe clipped for identification (Godley et al. 1981). This procedure is used widely on lizards and frogs with minimal effects on survival (see review in Ferner 1979) and thus seemed appropriate for turtles. However, because some individuals were missing toes naturally and because the large number of individuals processed increased the potential for marking errors, beginning in January 1978 all stinkpots were marked with plastic numbered Floy fish tags (4.8 cm. total length, 2.0 g.). The T-shaped Floy tags were inserted through a hole drilled in a posterior marginal scute of the turtle, and provided a rapid, easy means of positive identification (Godley et al. 1981:11). However, several Floy-tagged stinkpots were found drowned in the field, the Floy tag having snagged on vegetation, especially filamentous algae. Because Floy-tagging succeeded toe-clipping in time, we reasoned that yearly increases in the mean CL of S. odoratus (Tables 35-36) could result if smaller Floy-tagged animals were less capable of pulling free of entangling algae than larger ones.

306. To evaluate the potential effects of marking technique on differential survivorship, a series of comparisons were made testing mean carapace lengths of stinkpots at initial capture with those of recaptured turtles for both toe-clipped and Floy-tagged animals. Most toe-clipped S. odoratus were marked on permanent sites. To avoid the possible confounding effects of marking location on body size, all comparisons were made using only those animals initially captured on the permanent sites.

307. The results of these marking method comparisons were somewhat anomalous. For toe-clipped stinkpots the mean size of first-captured females (63.7 mm. CL, N=259) was significantly smaller (X^2=13.09, P=.0003) than recaptured individuals ($\bar{X}$=67.9 mm. CL, N=82). For males, no significant differences (X^2=0.01, P=.928) were detected between initial ($\bar{X}$=58.0 mm. CL, N=307) and final size ($\bar{X}$=57.8 mm. CL., N=92). For Floy-tagged stinkpots the opposite pattern among the sexes was obtained, i.e., recaptured males ($\bar{X}$=62.3 mm. CL., N=30) were significantly larger (X^2=9.98, P=.0016) than those intially marked ($\bar{X}$=55.6 mm. CL., N=39) but females showed no significant difference in mean CL (X^2=2.69, P=.1012). These analyses suggest that yearly shifts in the

mean body sizes of male and female S. odoratus on Lake Conway were not clearly associated with either marking procedure. At present, no explanation is available.

308. Table A5 presents yearly and pool comparisons of the mean relative densities of stinkpots on permanent site herp-patrols. Table A4 provides a similar analysis for funnel-trapped S. odoratus. For both sampling methods in all study years significant differences were detected among the pools. Densities on herp-patrols generally were highest in South and Middle Pools, intermediate in Gatlin and lowest in East and West Pools (Table A5). For funnel-trapped S. odoratus, densities were higher in Gatlin than in all other pools in each study year (Table A4). We suspect that the higher trap success in Gatlin was related mostly to the turbid waters in the littoral zone of this canal: stinkpots typically avoid traps set in clear water but more readily enter traps placed in murky water (J. Iverson, pers. comm.). South Pool funnel-trap point analyses provided in McDiarmid et al. (1983) showed that S. odoratus trap success was greatest at the ends of the transect between markers 0-50 and 380-460. These areas had a detrital substratum and were subject to chronic shoreline development resulting in localized patches of turbid water.

309. Comparisons of the yearly relative densities of Sternotherus odoratus indicate that this turtle declined in abundance on some of the permanent sites (Tables A4, A5). Significant yearly declines were detected for funnel-trapped individuals in South Pool (χ^2=18.54, P<.0001), Gatlin Canal herp-patrol animals (χ^2=23.24, P<.0005) and for pool totals by both sampling methods (funnel trap χ^2=26.86, P<.001; herp-patrol χ^2=15.25, P<.0005). In all of these significant comparisons, densities were highest in SY1 and declined the remaining years.

310. South Pool showed no detectable yearly changes in the relative density of herp-patrol stinkpots (Table A5) but funnel-trapped animals (Table A4) declined dramatically during the study especially following SY1; a similar pattern also occurred on the Middle Pool site (Tables A4, A5). At both of these sites, development of the shoreline for housing (McDiarmid et al. 1983:paragraphs 11-14) appears to have been the major cause of the declines in funnel-trap success for S. odoratus. Although no significant yearly reductions in the mean number of S. odoratus sighted per hour on herp-patrols at these

sites was recorded (Table A5), the total number of individuals seen on these permanent sites did decline noticeably during the study (Table A3).

311. At the East and West Pool sites, no differences in the relative density of S. odoratus were detected by either sampling method (Tables A4, A5), perhaps because of historically low densities at these sites. In Gatlin Canal, stinkpot densities declined significantly on herp-patrols (Table A5) but no changes were detected in funnel-trapped animals (Table A4). No shoreline development occurred at the Gatlin Canal site (McDiarmid et al 1983:paragraph 18) yet stinkpot herp-patrol densities declined dramatically after SY1 (Table A5). This site had the highest rate of interpool migration (Gatlin to West) of any site (see paragraph 295) and we suspect that many individuals moved from Gatlin Canal to West Pool or to Lake Gatlin possibly in response to repeated captures.

312. Comparatively little is known about the relative importance of various mortality factors for S. odoratus on Lake Conway. During the study 25 individuals were found dead in the field. Probable cause of death was not determined for 13 of these. Four adults apparently were killed by mammalian predators, and birds (probably boat-tailed grackles, Quiscalus major) killed two hatchlings. One male died of a fungal infection. Three individuals were found dead as a result of boat propeller strikes, and 77 (2.35%) of 3,273 live individuals showed damage from boats. We suspect that boat propellers are a major source of mortality for S. odoratus on Lake Conway. However, because of their small size probably few individuals survive a strike. In addition, those that die likely sink to the bottom of the lake and are difficult to find.

313. Ten of the 25 stinkpots found dead were marked animals; two were toe-clipped individuals and eight were marked with Floy tags. Two of the Floy-tagged specimens had drowned from entangling their tags in filamentous algae, and a third stinkpot was found alive but entangled in algae. The cause of death of the other eight S. odoratus was unknown; all were found washed up on shore. The ratio of toe-clipped to Floy-tag deaths (1:5) might suggest that mortality was higher for Floy-tagged individuals. However, both of the toe-clipped specimens but only three of the eight Floy-tagged stinkpots were found by our team; all others were recovered by local citizens or other contractors who noticed the conspicuous Floy tags. Stinkpots without these

tags (including toe-clipped individuals) rarely were brought to our attention. Hence, no definitive data are available to indicate that Floy-tagging relative to toe-clipping significantly increased mortality rates of stinkpots on Lake Conway.

Food Habits

314. Stomach contents of 410 Sternotherus odoratus from Lake Conway were available for study, thus providing the most complete dietary analysis for any herpetofaunal species on the lake system. Plant material accounted for 19.5% of the food biomass and occurred in 41.2% of the stomachs (Table 37). Six species of plants were identified, accounting for 77.7% of the total plant biomass in the stomachs. Of these identifiable species, Nuphar luteum (55.7%), Vallisneria americana (26.3%), filamentous algae (9.3%), and Eichhornia crassipes (8.2%) contributed most to plant biomass; Hydrilla verticillata and Potamogeton illinoensis were of minor importance. For both N. luteum and V. americana, seeds were the most commonly identified plant part, accounting for 59.0% and 29.2% respectively, of the biomass for each species.

315. A total of 2,779 animal prey items comprising at least 74 species were identified in the stomach contents (Table 37). In terms of the percentage of stinkpot stomachs containing the prey taxa and their respective numerical and biomass percent contributions, the dominant prey items were molluscs (64.1%, 54.8%, 57.5%) and aquatic insects belonging to the Lepidoptera (16.8%, 19.9%, 12.7%) and the Tricoptera (32.4%, 12.2%, 10.4%). As a class, insects accounted for 41.7% of the total number of animal prey and 37.8% of the animal biomass. Among the molluscs, gastropods were the dominant prey accounting for 96.1% of the mulluscan prey items and 94.4% of their biomass; bivalves (principally Corbicula fluminea and Anodonta sp.) were of minor importance (3.9% and 5.6% respectively). Among the five species of identified gastropods (N=1,272; 87.2% of total gastropods) the following rank-order of importance (% of total number of identified gastropods, % gastropod biomass contribution) was assigned: Melanoides tuberculata (58.8%, 29.0%), Planorbella duryi (21.4%, 30.4%), Pomacea paludosa (6.0%, 22.9%), Physa pulmilia (9.7%, 8.7%), and Viviparus georgianus (4.1%, 9.0%). Only 12.0% of the total stinkpots sampled had empty stomachs.

316. Sexual differences in the diet of S. odoratus on Lake Conway were

Table 37

The diet of 410 *Sternotherus odoratus* from Lake Conway.

	Number (%) of individuals containing prey taxa		Number (%) of Prey taxa		Weight (%) of prey taxa in g.	
EMPTY	45	(11.0)				
PLANT TOTAL	169	(41.2)			17.91	(20.0)
Eichhornia crassipes	7	(1.7)			1.07	(1.2)
Filamentous algae	28	(6.8)			1.21	(1.3)
Hydrilla verticillata	2	(0.4)			0.03	(0.0)
Nuphar luteum	38	(9.3)			7.25	(8.1)
Potamogeton illinoensis	1	(0.2)			0.03	(0.0)
Vallisneria americana	54	(13.2)			3.42	(3.8)
Other plants	30	(7.3)			4.93	(5.5)
ANIMAL TOTAL			2779	(100.0)	71.76	(80.0)
Mollusca			1523	(54.8)	34.40	(38.4)
Gastropoda	252	(61.5)	1459	(52.5)	32.34	(35.3)
Melanoides tuberculata	91	(22.2)	748	(26.9)	6.74	(7.5)
Physa pulmilia	50	(12.2)	124	(4.4)	2.01	(2.2)
Planorbella duryi	86	(21.0)	272	(9.8)	7.07	(7.9)
Pomacea paludosa	34	(8.3)	76	(2.7)	5.30	(5.9)
Viviparus georgianus	14	(3.4)	52	(1.9)	2.10	(2.3)
Bivalvia	23	(5.6)	60	(2.2)	1.93	(2.1)
Crustacea	27	(6.6)	27	(0.9)	6.48	(7.1)
Insecta	209	(51.0)	1158	(41.7)	27.19	(30.3)
Lepidoptera	69	(16.8)	553	(19.9)	11.68	(12.7)
Tricoptera	133	(32.4)	340	(12.2)	9.56	(10.4)
Other animals	56	(13.7)	98	(3.5)	10.17	(11.3)

detected. In general, males were more dependent than females upon aquatic insects (especially tricopteran and lepidopteran larvae), and less dependent upon gastropods. A greater percentage of males (14.6%) than females (7.1%) had empty stomachs, but fewer males (34.7%) than females (47.6%) contained plant material. In terms of the mean number of prey items per stomach, mean grams of animal material per stomach, and mean prey weight, females consumed more and larger prey than males (8.39, 0.29, and 0.04 versus 5.10, 0.14, and 0.03, respectively). The higher food intake of females relative to males probably is related to their greater mean biomass (female $\bar{X}$=51.2 g., N=1,330; male $\bar{X}$=33.4 g., N=1,574).

317. The diet of stinkpots also varied seasonally on Lake Conway. The percentage of individuals with empty stomachs was highest in winter, followed by fall, summer, and spring (Table 38). Among those stinkpots with food in their stomachs the following seasonal trends were observed: (1) the mean number of prey per turtle stomach was lowest in winter (3.71) followed by summer (6.78), fall (8.11) and spring (10.13), (2) both the mean total prey biomass and animal biomass per stomach were in rank-order agreement with each other and with the seasonal percentages of empty stomachs, and (3) the mean biomass of individual prey was lowest in fall (0.018 g.) and increased in winter (0.029 g.), spring (0.032 g.) and summer (0.036 g.). The seasonal percentages of turtles containing food and the mean total prey biomass in a season of turtles with food appear positively correlated with each other and with water temperature, suggesting that feeding activity in S. odoratus on Lake Conway was temperature dependent. The relationships between the mean number of prey per turtle, prey size, and season appear to be more complex. For example, the low number of prey per turtle in winter ($\bar{X}$=3.71) probably was related to low ambient temperatures, but the moderately low mean number of prey in summer (6.78) was countered by the highest mean biomass per prey (0.036 g.) for any season to produce relatively high total gut contents for stinkpots in summer ($\bar{X}$=0.308 g./individual). Because digestion and hence the rate of prey turnover in the stomachs of reptiles is positively correlated with temperature (Skoczylas 1978), we suspect that the total amount of food eaten per day by S. odoratus on Lake Conway was highest in summer, followed by spring, fall, and winter.

Table 38

Estimates of mean seasonal feeding activity of *Sternotherus odoratus* on Lake Conway based on stomach contents. Number and biomass estimates calculated using only turtles with food in their stomach.

	Winter	Spring	Summer	Fall
Sample size	65	83	92	169
Percent with empty stomach	21.54%	6.02%	7.61%	10.65%
Number animal prey per stomach	3.706	10.115	6.776	8.113
Total animal biomass per stomach	0.108 g.	0.322 g.	0.247 g.	0.146 g.
Biomass per animal prey	0.029 g.	0.032 g.	0.036 g.	0.018 g.
Total prey biomass per stomach	0.146 g.	0.373 g.	0.308 g.	0.191 g.

318. Among major taxonomic groups, plants occurred in proportionately more individuals in summer and fall than in other seasons (Fig. 52A); seeds of Vallisneria americana and Nuphar luteum were most important during the summer and fall when they were ripe. The contribution of mollusks to the diet remained high in all seasons, comprising between 31.9% (winter) and 40.5% (fall) of total prey biomass (Fig. 52C), and between 48.3% (summer) and 59.8% (fall) of the total prey number (Fig. 52B).

319. Among aquatic insects, lepidopteran and tricopteran larvae were the most important taxa (Table 37); these two groups also varied seasonally in their contribution to the diet of stinkpots (Fig. 52). Numerically, lepidopterans were most important in summer (Fig. 52B) but the mean weight of individual larvae (0.018 g.) was low compared to other seasons; hence lepidopterans showed no proportionate biomass increase in summer (Fig. 52C). In contrast, tricopteran larvae were most numerous in the diet in winter and spring; by summer most tricopterans had emerged and their contribution to prey biomass was lowest (Fig. 52C).

320. Yearly variation in five measures of feeding activity in S. odoratus is presented in Table 39. As indicated, the proportion of turtles with empty stomachs was much lower in SY2 than in the other years, which were similar. This fluctuation appears largely caused by yearly differences in the sample sizes taken in winter, the season with the highest percentage of empty stomachs ($\bar{X}$=21.5% for all years), i.e., only 10.5% of the SY2 sample was taken for gut analysis during the winter compared with a mean of 19.0% for the other two study years. To adjust for this possible seasonal bias, all measures of feeding activity in Table 39 were calculated using only those turtles with food in the gut; the same was done in Figure 53A.

321. Table 39 indicates the following trends: (1) the mean number of animal prey per stomach was substantially lower in SY1 than in the other two study years, (2) the mean total animal biomass per stomach was similar in SY1 and SY2 but higher in SY3, (3) as a result of these two factors, the mean biomass of individual prey was highest in SY1, intermediate in SY3, and lowest in SY2, and (4) the total mean biomass per stomach (including vegetation) increased in each study year.

322. Figure 53 displays yearly changes in the major types of prey eaten

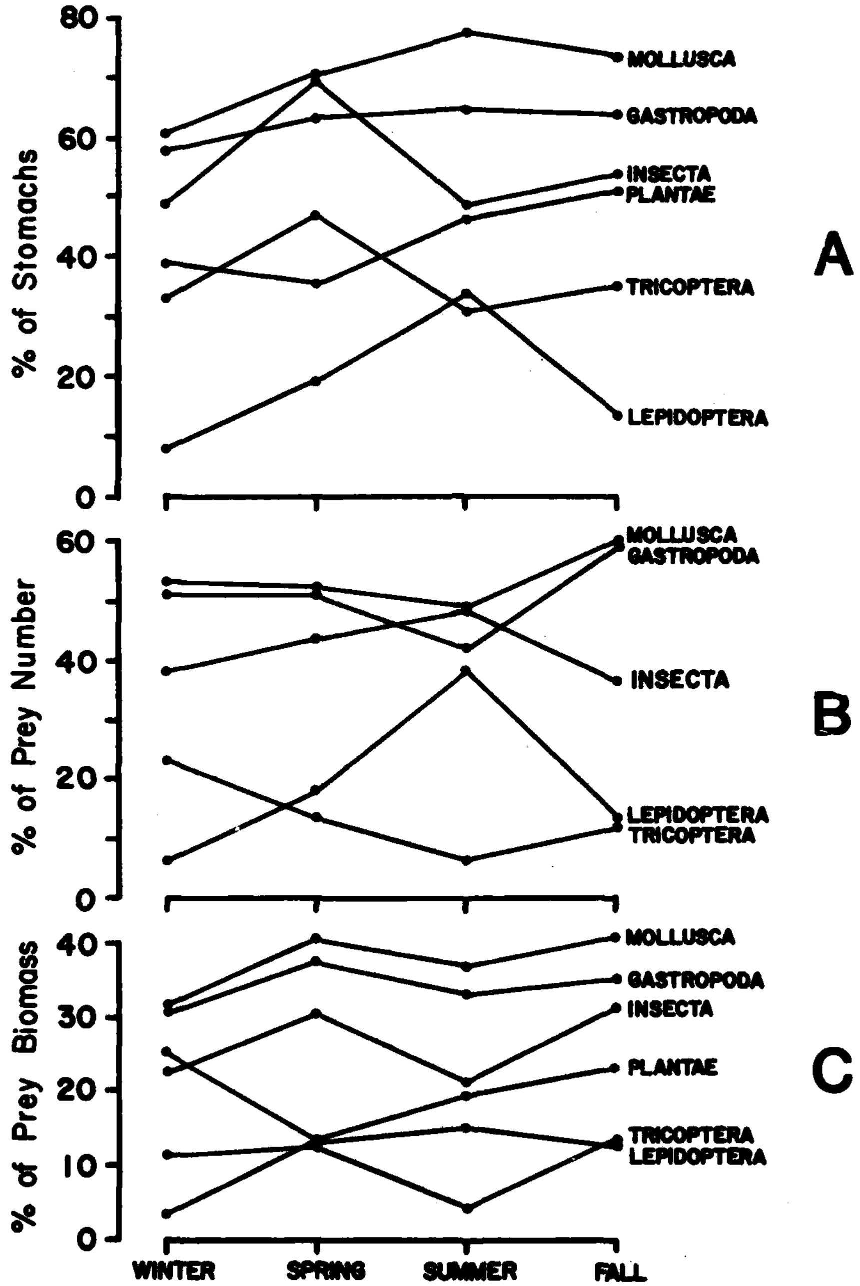

Figure 52. The distribution of major food items in the diet of Sternotherus odoratus from La Conw during each season of the three-year study. A = % of stomachs containing each food item, B = % of prey number contributed by each food item, C = % of prey biomass contributed by each food item.

Table 39

Estimates of mean yearly feeding activity of *Sternotherus odoratus* on Lake Conway based on stomach contents. Number and biomass estimates calculated using only turtles with food in their stomachs.

	Study Year 1	Study Year 2	Study Year 3
Sample size	131	151	127
Percent with empty stomach	16.79%	1.99%	14.96%
Number animal prey per stomach	5.474	10.621	10.907
Total animal biomass per stomach	0.183 g.	0.181 g.	0.250 g.
Biomass per animal prey	0.033 g.	0.017 g.	0.023 g.
Total prey biomass per stomach	0.229 g.	0.245 g.	0.282 g.

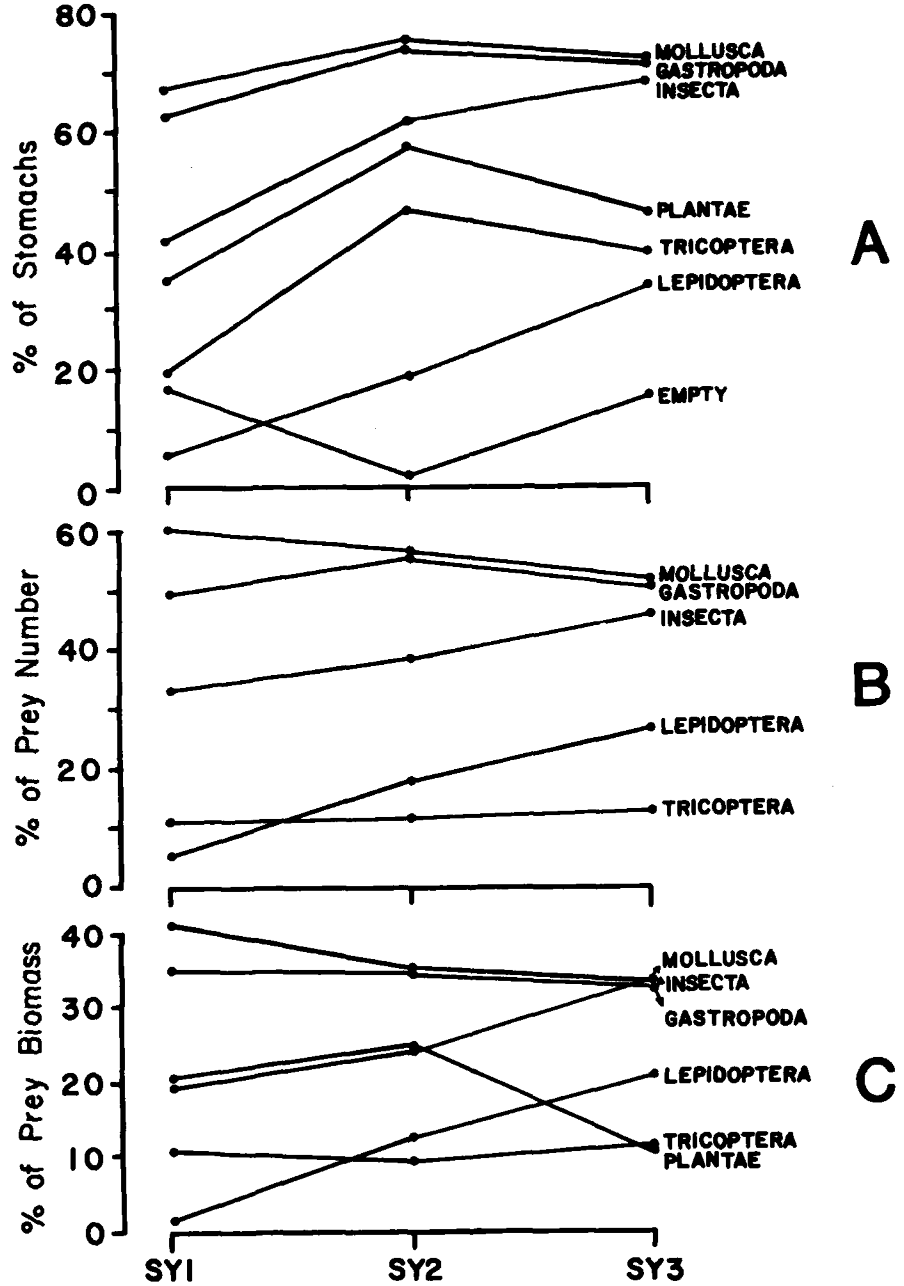

Figure 53. The distribution of major food items in the diet of Sternotherus odoratus from Lake Conway during each year of the study. A = % of stomachs containing each food item, B = % of prey number contributed by each food item, C = % of prey biomass contributed by each food item.

by S. odoratus on Lake Conway. Plant material comprised 20.2% to 25.9% of the diet in SY1 and SY2 but decreased to 11.4% in SY3 (Fig. 53C). The relative dietary importance of mollusks, and gastropods in particular, changed little during the study (Fig. 53A-C). However, examination of the relative contribution of specific species of mollusc indicates several consistent yearly trends. For example, planorbid snails (especially Planorbella duryi) accounted for 22.0% of the identifiable molluscan biomass in SY1, 35.3% in SY2, and 42.6% in SY3. A similar increase was seen in the snail Melanoides tuberculata (SY1=8.9% of mulluscan biomass, SY2=19.5%, SY3=39.3%). These increases were countered by reductions in the biomass contributions of Pomacea paludosa (SY1=28.8%, SY2=25.3%, SY3=5.2%), and bivalves, especially Corbicula fluminea (SY1=25.2%, SY2=2.1%, SY3=2.4%). The relative importance of aquatic insects in the diet also increased dramatically during the study (Fig. 53). This shift largely was caused by an increase in the numbers and biomass of nymphuline pyralid lepidopterans eaten; the contribution of tricopteran larvae and other insects remained relatively stable.

323. The gradual yearly increases in the mean weight of the total stomach contents in Table 39 were correlated with yearly increases in the mean body sizes of stinkpots (Tables 35-36) on Lake Conway suggesting that no real yearly increase occurred in the total amount consumed per gram of turtle mass. However, the total biomass of animal prey per stomach showed a substantial rise between SY2 and SY3. This shift was related to two factors: (1) reduction in the importance of plant material in the diet (Fig. 52C), and (2) a significant decrease in the availability of macrophytes on Lake Conway as a result of white amur feeding activity (Schardt et al. 1981). The lower mean number of animal prey items per stomach (5.474) and the correspondingly larger mean prey size (0.033 g.) during SY1 compared with other study years is at present poorly understood. One possibility is that we became more adept at separating and identifying the crushed fragments of prey in the gut contents as the study progressed. However, the number of identified prey taxa did not change substantially during the study, i.e., 66 taxa were categorized (in 109 S. odoratus containing food) in SY1 compared with 75 (148) in SY2, and 50 (108) in SY3. Clearly, more detailed study in this regard is needed.

324. Yearly changes in the relative importance of the various prey taxa

shown in Figure 53 appear most related to the trophic positions and life history characteristics of the prey, and the effects of macrophyte removal by white amur on both the prey species and on our sampling success. Our analyses (Fig. 53 and paragraph 322) showed that the mollusc species Planorbella duryi and Melanoides tuberculata increased in the diet while Pomacea paludosa decreased. F.G. Thompson, senior malacologist at the Florida State Museum, stated (pers. comm.), that M. tuberculata is a bottom-dwelling detritivore, whereas P. paludosa principally grazes aufwuchs off shallow-water, submerged macrophytes. We suspect that M. tuberculata populations on Lake Conway have increased possibly in response to higher levels of detritus (e.g., white amur feces) while P. paludosa has decreased in abundance as its feeding substrata (macrophytes) were removed. P. duryi feeds primarily on filamentous algae and on the young shoot-tips of macrophytes. As noted earlier (paragraph 219) we suspect that filamentous algae may have increased in abundance on the lake system as light on the lake bottom increased with the elimination of taller macrophytes. Among the aquatic insects, leptocerid tricopteran larvae (primarily Nectopsyche spp.) showed no change in the diet of stinkpots (Fig. 53). These bottom-dwelling, sand-grain case building insects (Merritt and Cummins 1978) were common in all shallow, sandy habitats on Lake Conway, and seemed not to require a macrophyte overstory. Thus, white amur probably had little effect on their densities, and as a result, their relative abundance in the diet of stinkpots did not vary with study year. In contrast, nymphuline lepidopteran larvae increased markedly in the diet of stinkpots during the study (Fig. 53). On Lake Conway these pyralid moth larvae were associated with and fed primarily on the leaves of Vallisneria americana. Their increase in the diet of S. odoratus probably was the result of two factors: (1) V. americana increased 82.8% in coverage in the lake system from 1977 to 1980 (Schardt et al. 1981: Fig. J10), and (2) as white amur drastically reduced the coverage of Potamogeton illinoensis, it became increasing difficult to find stinkpots in any habitat other than V. americana.

325. In summary, the diet of Sternotherus odoratus on Lake Conway was dominated by prey which were largely immobile and used crypsis as a means of avoiding detection and included such items as plant seeds, molluscs, tricopteran and lepidopteran larvae. Female turtles, which averaged larger in

body size than males, consumed more and larger prey. The feeding activity and diet of stinkpots also changed seasonally, apparently in response to cyclic fluctuations in water temperature and the divergent life-history patterns of the prey species.

326. Apparent yearly shifts in the feeding ecology of stinkpots also were detected including (1) a reduction in the biomass contribution of macrophytes and a corresponding increase in animal prey, (2) changes in the relative abundances of certain species of snails in the diet, and (3) an increase in the importance of aquatic insects, especially lepidopteran larvae. All of these dietary changes were more clearly associated with macrophyte removal by white amur than with any other factor. However, we caution that more extensive quantitative analyses of existing data are needed to more clearly define this apparent cause and effect relationship. For example, did sexual and seasonal differences in diet have a signficant interaction with study year, and if so, how might this affect our interpretations? The University of Florida (e.g., Crisman and Kooijman 1981) has provided WES with extensive information on the distribution and abundance of benthic invertebrates by habitat on Lake Conway. Do these prey availability data confirm our impressions about changes in the relative and absolute abundances of prey species on Lake Conway? If so, how has availability influenced prey selection and the rate of food intake of Sternotherus odoratus on Lake Conway? The answers to some of these intriguing questions may be forthcoming. Ms. N. N. Rojas has initiated a detailed study of the foraging ecology of S. odoratus on Lake Conway; these results should be available within a year.

Growth and Reproduction

327. The large sample of male (N=74) and female (N=90) S. odoratus captured more than 90 days apart permitted a more extensive analysis of growth than possible for other herpetofaunal species on Lake Conway. We used the von Bertalanffy general growth model (Bertalanffy 1957) of the form growth rate (in mm. CL./yr.) = a-b x CLi, where a is the initial growth rate and b is a damping coefficient, and CLi is the carapace length at first capture. This model predicts that growth in CL is a linear function of CLi, and that the asymptotic size is - a/b.

328. Figure 54 shows growth rates of S. odoratus on Lake Conway fitted by

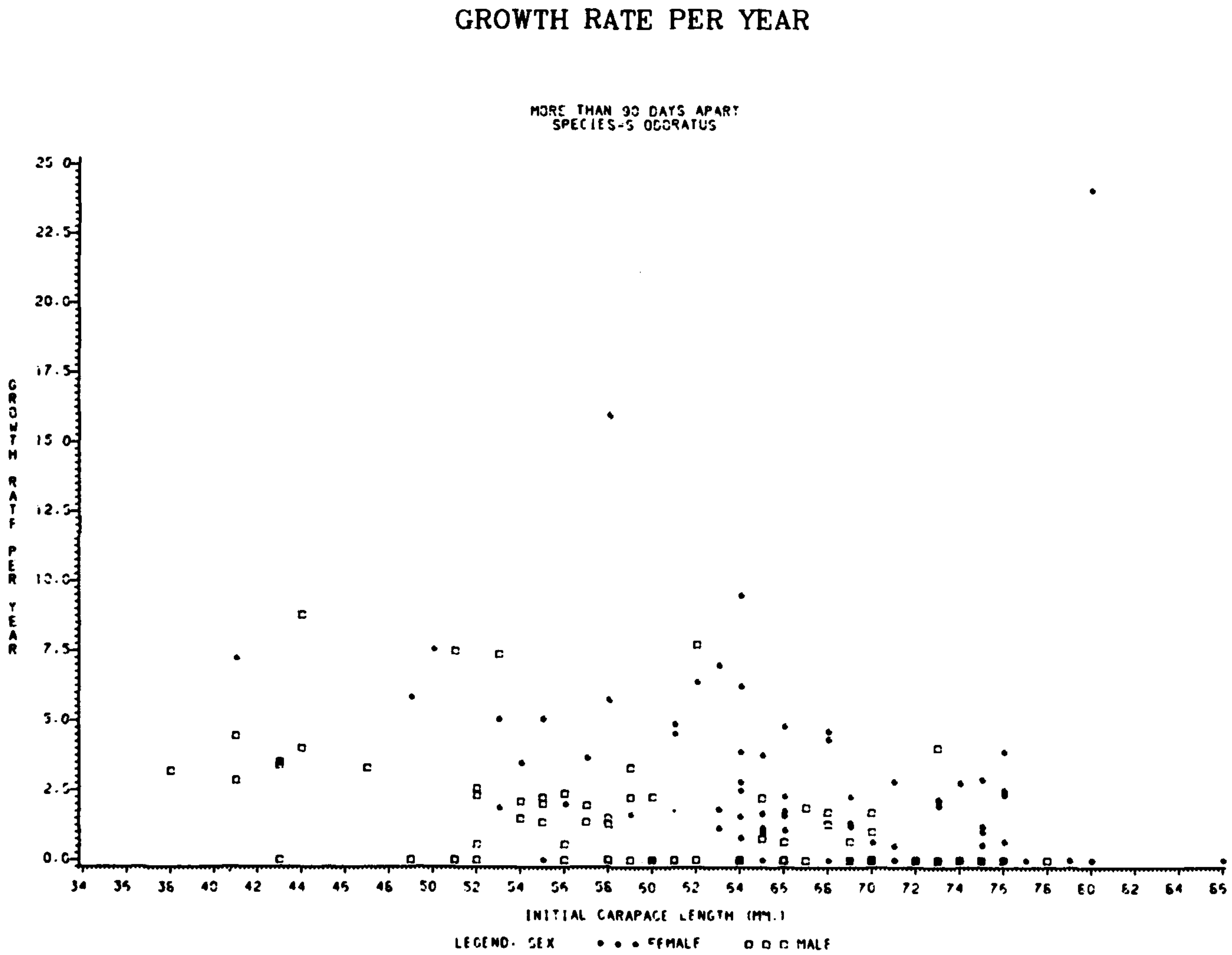

Figure 54. Relationship between growth rate (mm. CL/year) and initial carapace length in recaptured male and female Sternotherus odoratus from Lake Conway.

the von Bertalanffy model. Growth rate (GR) equations for males (GR=7.354-0.099 CLi) and for females (GR=14.084-0.178 CLi) were significantly different from one another with females growing at a faster rate and attaining a larger asymptotic size than males. However, the model accounts for only 22.8% and 38.6% of the variance in male and female growth rates, respectively. In addition, the predicted maximum size of males (74.3 mm. CL) and females (79.2 mm. CL) underestimated the observed maximum of males (83 mm. CL) and females (92 mm. CL) by 10.5% and 13.9% respectively. At larger body sizes a higher proportion of both sexes showed no growth (Fig. 54), suggesting that growth slows with the advent of sexual maturity, and that a more complex polynomial regression is needed to predict maximum size in this species. We suspect that the high variance about these regression lines was caused by several factors: (1) measurement error ($\pm$ 1 mm.) was high relative to the growth rate, and (2) the model provides an instantaneous estimate of growth for individuals. The high variance in the interval between captures (90 to 1,328 days) produced a correspondingly high variance in growth rate. Restricting the growth measurement period to smaller intervals (e.g., 90-150 days) severely reduced the sample sizes and, (3) differences among individuals, pools, seasons, and study years may have contributed to the high variance, but the sample sizes necessary to detect these differences were not available.

329. Growth data from the field was available for relatively few juvenile S. odoratus (Fig. 53). To examine maximum potential growth rates of S. odoratus, four juveniles hatched from eggs of Lake Conway females in early July 1980, were fed an ad libitum diet of Shrimp-el-etts (Hartz Mountain Corp.) frozen brine shrimp and Mealtime (Kal Kan) under laboratory conditions beginning in late August 1980 (Fig. 55). Based on known minimum average size at sexual maturity of field-collected stinkpots (paragraph 332) the male reached reproductive size in 1.4 years, and the females in 1.4, 1.8, and 1.9 years, respectively. On 10 January 1982, the largest female (then 62.5 mm. CL.) was observed copulating with the male. Thus, using copulation as a criterion of reproductive maturity, Lake Conway stinkpots raised under laboratory conditions can mature in about 1.5 years.

330. The mean annual growth rate of the laboratory-raised stinkpots was 15.65 mm. CL for the male and 21.93 mm. CL for the three females. These

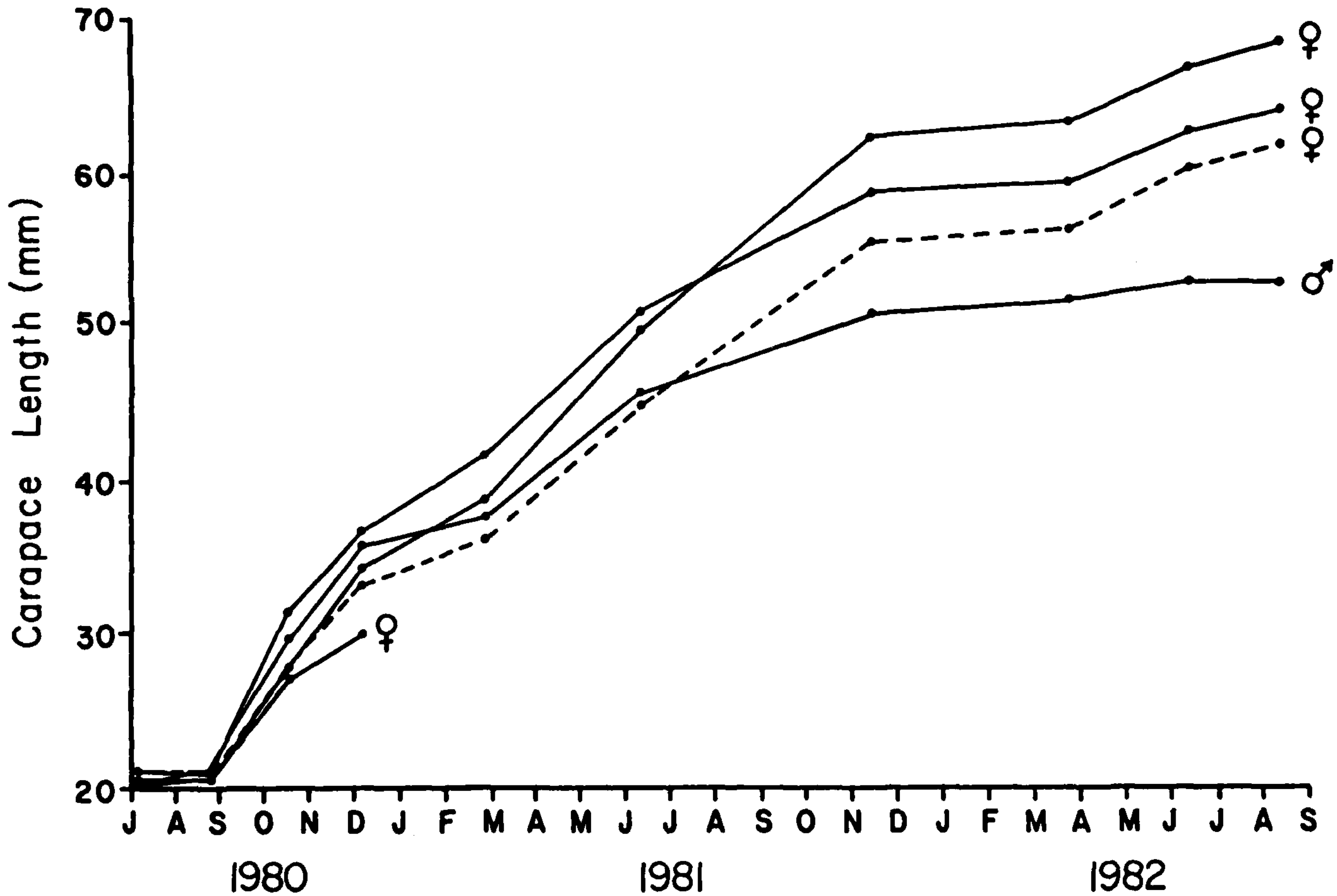

Figure 55. Growth rates of five Sternotherus odoratus, four females and one male, raised in the laboratory.

estimates are about two times the mean maximum growth rates of field-collected males (7.35 mm. CL) and females (14.08 mm. CL) (Fig. 55). However, the growth intervals and CLi's were quite different making direct comparisons difficult. We suspect that growth is considerably slower in the field than in the laboratory, even for very young S. odoratus. Our best estimate is that both sexes of this species mature in about three years on Lake Conway, but some slow-growing females may delay reproduction until four or five years of age.

331. D. Gross (1982) studied the reproductive biology of Sternotherus odoratus on Lake Conway in partial fulfillment of her Master's degree at U.S.F. Thus, a thorough analysis of reproduction in this species is available, and only a brief summary is provided here.

332. On Lake Conway, the smallest mature female was 57 mm. CL and the largest immature female was 64 mm. CL (N=208). Of 162 necropsied females 62 mm. CL or larger, 97.5% were reproductively mature. The average size at sexual maturity of females on Lake Conway was about 60 mm. CL. The smallest male with enlarged testes or epididymides was 48 mm. CL, and average size at sexual maturity was about 50 mm. CL.

333. The reproductive season of female S. odoratus in Lake Conway extended from December through August, when mature females had ovarian follicles ($\geq$ 11.0 mm. diameter), oviducal eggs, or enlarged corporea lutea ($\geq$ 4.0 mm. in length) (Fig. 56). An ovarian quiescent period occurred from September through November. The number of oviducal eggs present in a female ranged from one to three ($\bar{X}$=1.74, N=53), and was positively correlated with CL. Females laid an estimated maximum of six clutches per reproductive season, and the estimated maximum number of eggs laid by a female per season was 16. Most females probably lay between five and ten eggs per season.

Trionyx ferox (Florida softshell)

Distribution and Habitat Preferences

334. A total of 29 softshelled turtles was collected on Lake Conway but 43 individuals were observed (Table A2). Most observations were from South (N=15), Middle (9), and East (8) Pools, and Lake Gatlin (9). Only two individuals were observed in West Pool (Table A2). The relative rarity of T.

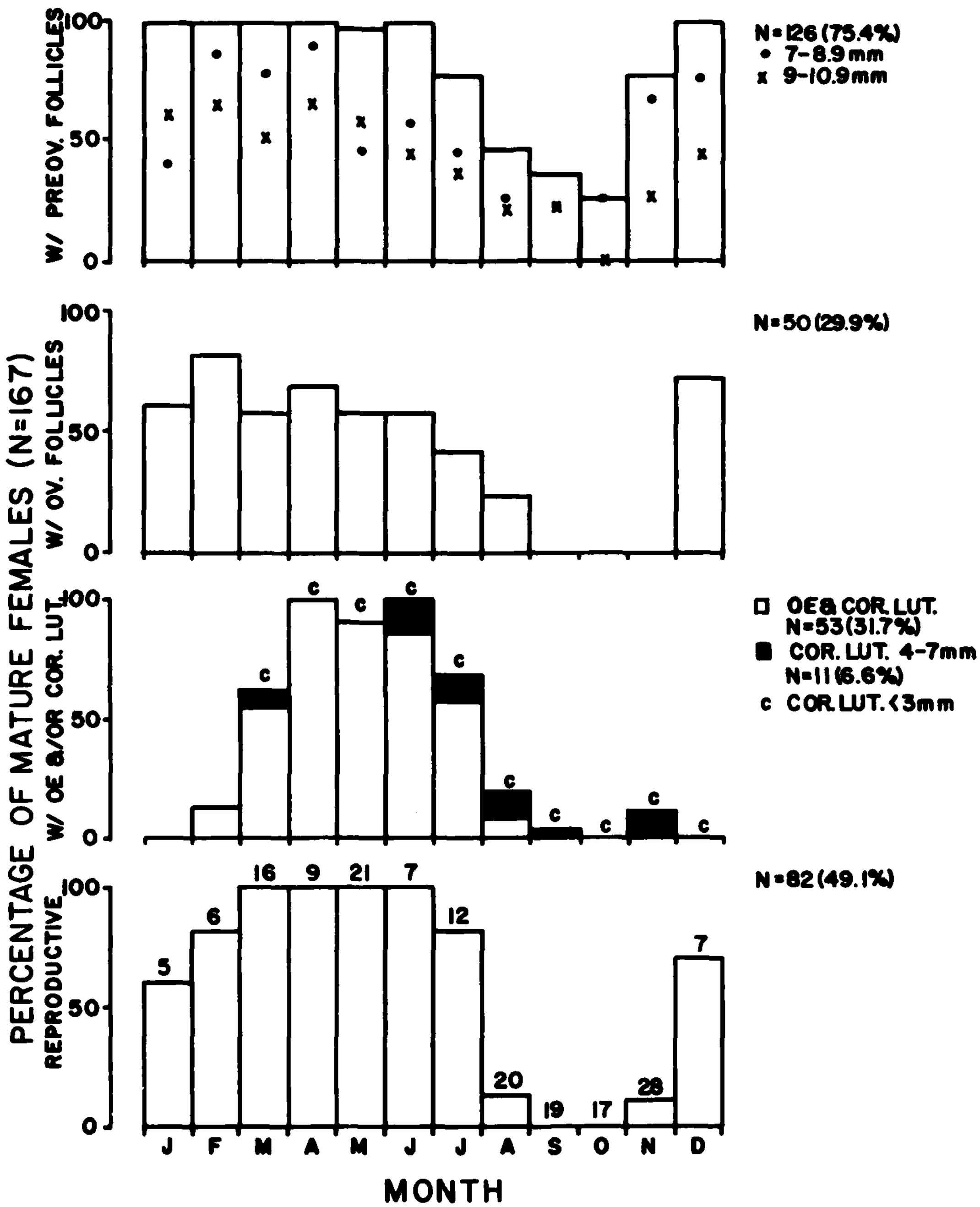

Figure 56. Monthly percentages of mature female Sternotherus odoratus with various reproductive components (PREOV. = preovulatory, OV. = ovulatory, OE = oviducal egg, COR.LUT. = corpora lutea). See Gross (1982) for details.

ferox in West Pool probably was greater than our samples indicate. For example, during diurnal boat trips through the Lake Conway chain on warm, calm summer days it was not unusual to see the heads of six or more T. ferox on the water's surface of all pools except West Pool, where they were conspicuously absent. Why T. ferox was rare in West Pool is unknown. Interestingly, a similar scarcity of Pseudemys floridana and P. nelsoni (see respective species accounts) existed in West Pool.

335. Habitat information was available for 30 T. ferox. Seventeen individuals were observed in open water, 12 in the littoral zone, and one nesting female was found on shore. Most specimens (N=28) were observed in water less than 1.0 m. deep. Of 27 individuals for which dominant vegetation was recorded, 12 were associated with Potamogeton illinoensis, five with Vallisneria americana, two with bare bottom, two with beach, two with Panicum hemitomon, and one each with Nitella megacarpa, Nuphar luteum, Panicum repens, Pontederia lanceolata and Typha latifolia. Thus, softshells occurred in most of the available habitats on Lake Conway.

Activity Patterns

336. Because T. ferox was rarely captured, little information was available concerning their activity or movements. Active (swimming) animals were seen both day and night. T. ferox was the only turtle species on Lake Conway that showed a distinct summer activity peak with four observed in winter, 11 in spring, 29 in summer and seven in fall (χ^2=29.54, P<.01).

337. Plummer and Shirer (1975) studied the movements of individuals in a river population of Trionyx muticus in Kansas. In this linear habitat, the mean home range of males (474 m.) was smaller than that of females (1,228 m.), but some individuals of both sexes moved great distances (up to 21.8 km.). These data suggested that the home ranges and movements of T. ferox on a large lake system such as Lake Conway may be quite extensive.

Population Demography

338. Figure 57 shows the size frequency distribution for 28 T. ferox collected on Lake Conway. This figure probably underestimates the relative proportion of adults in the population. Adult T. ferox are fast, agile swimmers and thus more difficult to catch. In addition, adults apparently spend most of their time offshore in deeper water where little sampling was

LAKE CONWAY HERPETOFAUNA DATA

ALL DATA
SPECIES=T.FEROX

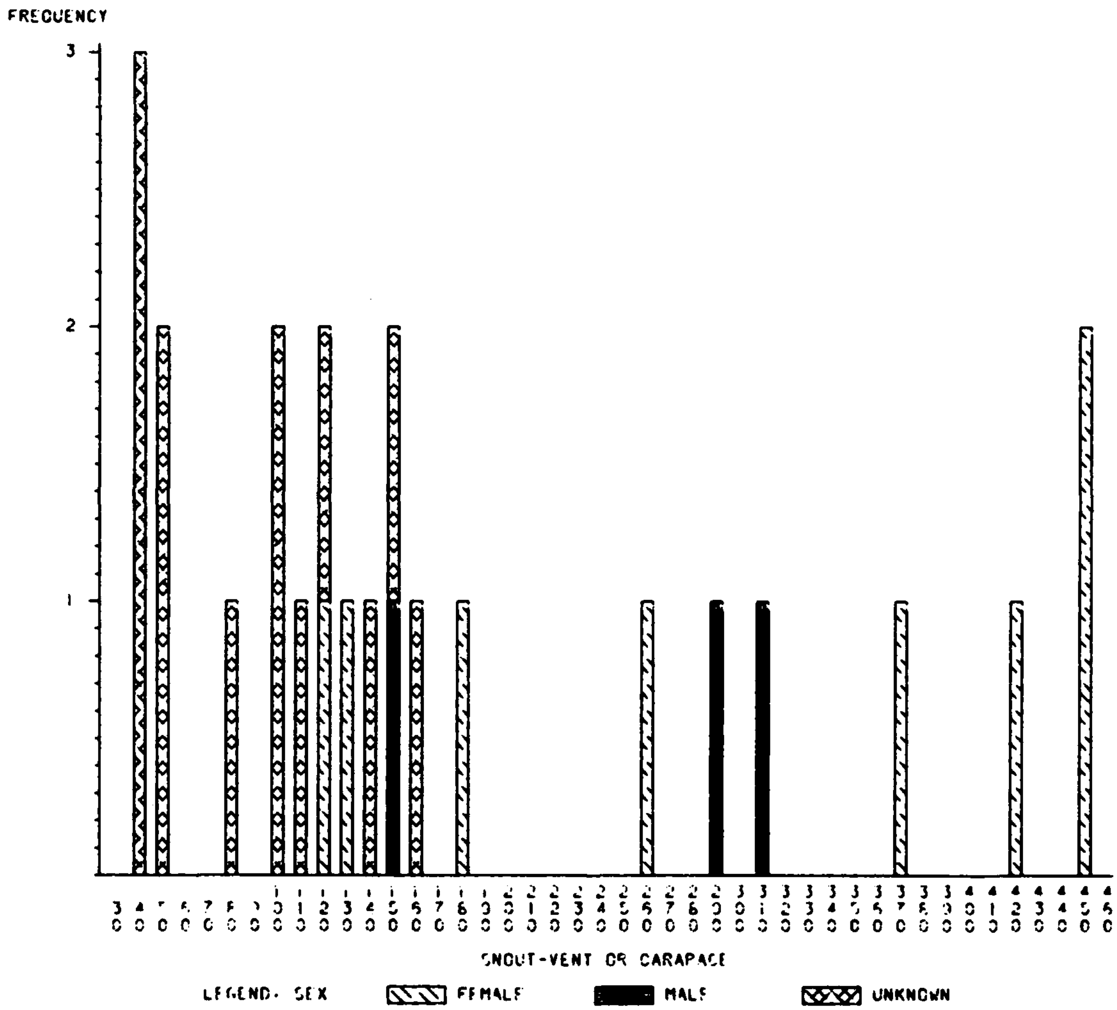

Figure 57. The size frequency distribution of Trionyx ferox on Lake Conway.

done. Figure 57 suggests that females of T. ferox grew to larger adult size than did males as has been reported previously (Ernst and Barbour 1972). The largest female collected on Lake Conway (450 mm. CL) weighed 8.45 kg., the largest male (308 mm. CL) weighed 2.85 kg. Thus, adult T. ferox and Chelydra serpentina attain the largest sizes of any turtle species on Lake Conway.

339. Only two of 29 marked T. ferox were subsequently seen again and little is known about population size in this species. However, softshells probably are much more abundant on Lake Conway than our samples indicate. No significant differences in relative density in T. ferox either between years or between permanent sizes (Table A3) were detected, possibly because of the small sample sizes for this species. (see paragraph 334).

Food Habits

340. The stomach contents of four T. ferox from Lake Conway were examined. Two juveniles (129 and 165 mm. CL) contained no food, and another (151 mm. CL) had 1.87 g. of aquatic insects and snails in its gut. One adult female (373 mm. CL) had eaten nine large snails, Pomacea paludosa (80.73 g.), and an unidentified fish (4.82 g.). The only detailed study of the food habits of T. ferox is by Dalrymple (1977). He found that juveniles feed extensively on aquatic insects but switch to primarily a fish and snail diet at maturity.

Reproduction and Growth

341. Ernst and Barbour (1972) and Webb (1973) reviewed what is known of reproduction and growth in T. ferox. Females mature at approximately 220 mm. CL and males at 170 mm. CL. From four to 22 eggs are deposited from mid-March through July; most females probably nest several times per year. At Lake Conway three fresh T. ferox eggs were found in shallow water on 26 June 1979 in Middle Pool and four eggs were found under similar circumstances on 27 June 1980 in South Pool. One female was observed attempting to nest on 15 June 1980 in South Pool.

342. One juvenile (146 mm. CL) T. ferox originally captured in East Pool in May 1978 was found dead in April 1981. This individual had matured (male) and grown 47 mm. in CL.

REPTILIA: SQUAMATA

343. Seven species of harmless snakes belonging to the family Colubridae

are known from Lake Conway. Two of the species (*Coluber constrictor*, *Thamnophis sirtalis*) occur mostly along the lake's edge; the other species (*Farancia abacura*, *Nerodia cyclopion*, *N. fasciata*, *Regina alleni*, and *T. sauritus*) are semi-aquatic and more likely to be encountered in the water than on shore. All of these species are restricted to the littoral zone and near-shore environment.

344. As a group snakes were a minor component of the Lake Conway herpetofauna, accounting for only 2.53% of the total observations (Table A1). Most (85.43%) of these records were from the permanent sites and four of the seven species were known only from these sites. The two water snakes (*Nerodia* spp.) were moderately common on the lake system and together accounted for 88.41% of the records for snakes.

Coluber constrictor (Black Racer)

345. Black racers typically are terrestrial snakes (Conant 1975) and normally would not have been considered in this report. However, one specimen was collected in an aquatic drift fence on 7 December 1977 at the South Pool permanent site (another was seen on the shore at this same site on 14 October 1977). The species probably occurs along the undeveloped shores of other pools, where it feeds on frogs, other snakes, and small mammals (Conant 1975).

Farancia abacura (Mud snake)

346. Six mud snakes were collected on Lake Conway: four from the South Pool permanent site, one from the Gatlin Canal site, and one from along the shoreline west of the East Pool site (Tables A2 and A3). Four were taken by shoreline census (all live specimens found prowling the shoreline or under debris) and two in funnel traps (Table A1). The one mud snake from Gatlin Canal was found dead along the shore with its head chopped off. All *F. abacura* were collected along densely vegetated shorelines with a muddy substratum. Beds of pickerelweed (*Pontederia lanceolata*), waterhyacinth (*Eichhornia crassipes*) and cattail (*Typha latifolia*) appear to be the preferred habitats.

Presumably, mud snakes occur in suitable habitat in the other pools.

347. Little is known about the activity patterns or demography of mud snakes on Lake Conway. Active adults (545-1,280 mm. SVL) were collected in January, June, September (2), and November; one 316 mm. SVL juvenile was taken 8 m. on shore under a board in March. None of the five marked individuals was recaptured. The diet of adult F. abacura consists almost entirely of Siren and Amphiuma spp. (Carr 1940, Wright and Wright 1957), thus it is surprising that mud snakes were not more common on the East and West Pool sites, which yielded 79.7% of these aquatic salamanders (Table A4). Adult females deposit in early summer between 11 and 104 eggs which usually hatch by fall (Wright and Wright 1957).

Nerodia cyclopion (Green water snake)

Distribution and Habitat Preferences

348. Green water snakes were the most frequently observed ophidian on Lake Conway. Although this large, semi-aquatic species only accounted for 1.95% (N=233) of the total herpetofaunal observations on the lake system, 77.15% of the total records for snakes were N. cyclopion (Table A2). Green water snakes were widely distributed on Lake Conway. Most (46.4%) individuals were observed in South Pool, followed by East (24.9%), Gatlin and Middle (10.7% each) and West (7.3%) (Table A2); permanent shoreline sites accounted for 85.4% of the total records (Table A3). N. cyclopion was taken by a variety of methods; herp-patrols (38.20%), funnel-traps (33.48%) and shoreline censuses (23.61%) were the most productive sampling procedures for this species (Table A1).

349. Funnel-trap captures provided the best means of evaluating habitat selection in green water snakes because the availability of each habitat was measured independently (see Appendix A of Godley et al. 1981, and Appendices A and B of McDiarmid et al. 1982 for availability data). Mean capture rates of N. cyclopion per 100 trap days (± 95% confidence limits) for each of the dominant littoral zone vegetation types on the permanent sites were as follows: Fuirena scirpoides ($\bar{X}$=1.161 ± 0.604), Typha latifolia (0.976 ± 0.720), Panicum repens (0.971 ± 0.773), Pontederia lanceolata (0.811 ± 0.457), Eichhornia crassipes (0.569 ± 0.262), Nuphar luteum (0.505 ± 0.987), Panicum hemitomon

(0.280 ± 0.548), white sand beach (0.056 ± 0.109). In this analysis the relative trap success in F. scirpoides and P. hemitomon is somewhat misleading. At sites where the two plants were syntopic on Lake Conway, panic grass typically dominated the deeper, outer fringe of the littoral zone (where traps could not be set effectively) while lake rush occupied the inner, trapable zones. Observations presented below suggest that P. hemitomon was used by N. cyclopion to a much greater extent than shown by our trapping results.

350. N. cyclopion also occurred in all designated substrate categories on Lake Conway (see paragraph 26). Highest mean densities (1.722 to 2.032 snakes/100 trap days) were recorded at trap stations with 11-20 cm. of detritus; stations with more or less detrital material yielded fewer individuals (range = 0.344 to 0.552 snakes/100 trap days). The occurrence of at least moderate densities of green water snakes in most habitat types (except beaches) suggests that this snake treats plant species in a fine-grain manner, i.e., although vegetation seems required for existence, the particular type of plant was less important. Possibly plant density or some other physical aspect of the littoral zone community was of more proximate importance to the snake, perhaps through its influence on prey populations (chiefly fish) or by affecting concealment and protection from predators.

351. Microhabitat information also was available for 74 N. cyclopion observed on herp-patrols and on shoreline censuses. Most individuals (51.35%) were found in the littoral zone, but shallow, open water habitats (29.73%) and terrestrial environments (18.92%) also were occupied by green water snakes to different degrees in different seasons (see paragraphs 355-356). Most littoral zone sightings were in Panicum hemitomon (N=15) followed by Eichhornia crassipes (14); other plant species yielded two to six sightings each. All open water observations occurred over Potamogeton illinoensis or Vallisneria americana, the only plant species that were abundant in the shallows of Lake Conway. The average distance from the littoral zone that snakes were seen in open water was 9.98 m. ($\bar{X}$ water depth = 1.02 m.), but some individuals ventured out at least 40 m. Of the 14 N. cyclopion found on shore, all were within 25 m. of the water's edge (see also paragraph 356).

352. Only one N. cyclopion (an adult female, 720 mm. SVL) was radiotelemetried on Lake Conway. This individual was located 63 times between

14 December 1979 and 12 September 1980 on the East Pool islands. The dominant vegetation at most of her locations was Eichhornia crassipes (N=56) followed by Pontederia lanceolata (6), and Typha latifolia (1). These values were in rank-order agreement with the relative abundances of the three littoral zone plant species within the home range of this individual. This female was never recorded in open water or terrestrial habitats.

353. In summary, Nerodia cyclopion was the most abundant snake species in Lake Conway, and occupied most of the vegetated shoreline. White sand beach was the only littoral zone habitat that clearly seemed to be avoided. Both adjacent open water and terrestrial environments were frequented by this species but neither was sufficient: relatively densely vegetated, undisturbed sections of shoreline were required for the maintenance of N. cyclopion populations on this lake system.

Activity Patterns

354. During dawn and dusk trap checks in SY1, 52.0% of 50 Nerodia cyclopion were captured during daylight hours (χ^2=0.12 P>.85). Seasonal differences in the proportion of individuals entering funnel traps during the day in spring (55.6%, N=9 total captures), summer (57.1%, N=28), and fall (38.5%, N=13) were not significant (χ^2=1.55, P>.40); none was collected in traps in winter. In Louisiana, N. cyclopion exhibited a distinct unimodal pattern of nocturnal activity, peaking in mid-summer (Mushinsky et al. 1980).

355. Figure 58 suggests that aquatic sightings of green water snakes on permanent-site nocturnal herp-patrols peaked in spring and fall with an apparent lull in June and July, and in winter. However, the mean number of N. cyclopion captured per 100 funnel-trap days was highest in summer (1.432), followed by fall (1.147), spring (0.492), and winter (0.040). Three months (July $\bar{X}$=2.059/100 trap days, August $\bar{X}$=1.854, September $\bar{X}$=2.100) accounted for 70.1% of the funnel trap captures but represented only 28.1% of the total trap days. This suggests that N. cyclopion was active in the water from spring through fall. Differences between herp-patrol and funnel trap capture rates in summer probably reflect real differences in habitat selection, i.e., during summer N. cyclopion probably spent most time in the littoral zone where they were more susceptible to funnel traps than to herp-patrols, which most effectively sampled animals occurring in open water. Figure 59 summarizes

LAKE CONWAY HERPATROL RESULTS FOR EACH MONTH

FIRST THREE YEARS INCLUDED
SPECIES-N.CYCLOPION

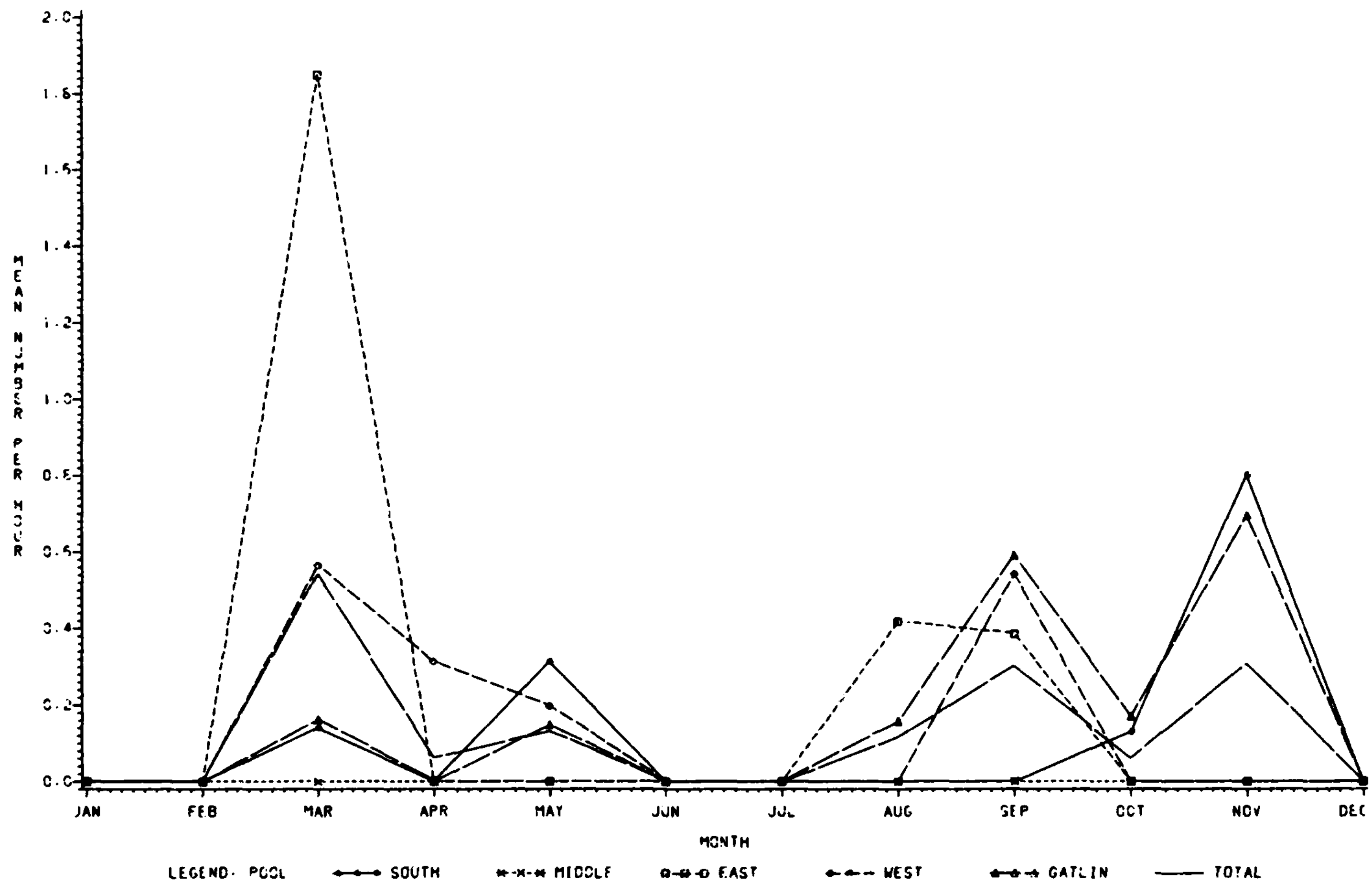

Figure 58. The mean number of Nerodia cyclopion sighted per hour in each month on the permanent site herp-patrols.

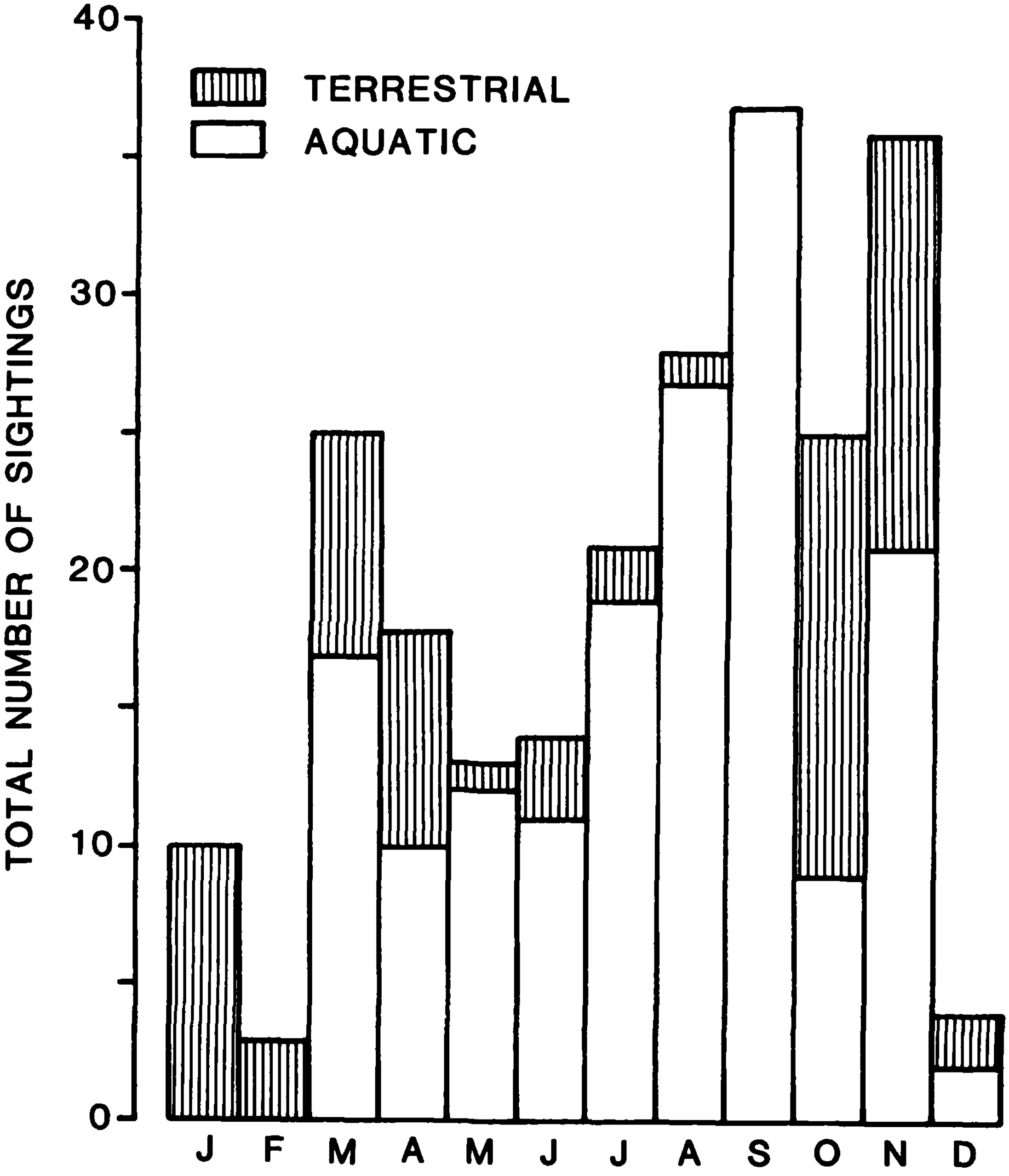

Figure 59. The monthly total number of sightings of *Nerodia cyclopion* in terrestrial and aquatic habitats on Lake Conway.

monthly observations of N. cyclopion encountered in terrestrial (i.e., on shore or basking on emergent vegetation and aquatic (i.e., snake's body in water) habitats on Lake Conway. Most (89.9%) terrestrial sightings were confined to the cooler months (October through April) whereas most aquatic sightings (64.2%) were recorded from May through September. Total snake activity peaked in spring and fall. In Louisiana, Mushinsky et al. (1980) found similar temporal shifts in terrestrial and aquatic sightings of N. cyclopion but total activity peaked in summer.

356. The tendency of N. cyclopion to move onto shore or bask on emergent vegetation during the cooler months had important implications for their survivorship at different sites on Lake Conway. Our understanding of the activity cycles of N. cyclopion was most complete for the South Pool site, where 44.2% of the total sample for this species was obtained, mostly in SY1 (Table A2, A3). Shoreline censuses produced 48.6% the total observations for N. cyclopion at this site. We found that during spring and fall this species typically was aquatic but often spent the morning and mid-afternoon hours basking on emergent vegetation, especially mats of Panicum hemitomon or Pontederia lanceolata. During summer, little basking occurred. However, once water temperatures dropped below 16 C in winter, N. cyclopion left the aquatic environment and overwintered in cotton rat (Sigmodon hispidus) burrows on shore. Of 17 individuals observed during winter months (Fig. 59), 15 were found basking at the entrances of rodent burrows. These terrestrial observations (N=13) were confined chiefly to the South Pool site. Despite considerable field effort in winter months at other permanent sites, relatively few N. cyclopion were found on shore. We suspect that at several of the other permanent sites (i.e., Middle and East Pools) with extensive areas of marsh, N. cyclopion may overwinter in aquatic habitats, such as beneath thick aquatic vegetation or in burrows of round-tailed water rats (Neofiber alleni). The single female N. cyclopion radiotracked on East Pool overwintered in the aquatic environment. Such behavior apparently is characteristic of the species in Louisiana (H. Mushinsky, pers. comm.). Comparable aquatic overwintering habitats were not apparent at the South Pool site.

357. Movement and home range information were available for nine N. cyclopion (seven from South and two from East Pools) recaptured 14 times, and

for the radiotracked female from East Pool. The mean distance between captures for the nine individuals was 202.3 m. (range = 0-310 m.) with 11 of 14 recaptures greater than 100 m. apart. Importantly 12 of 14 recaptures were from the South Pool site which contained only 460 m. of vegetated shoreline; none was recaptured away from this littoral zone "island". Several of these individuals traversed nearly the entire length of the site; one moved 140 m. in 2.0 hrs., another 223 m. in 1.67 hrs. From these data we conclude that the home ranges of some N. cyclopion are large and that habitat availability may confine home range size more than the mobility of the snake. In contrast to many of the South Pool animals, the female N. cyclopion radiotracked on the East Pool islands had a small home range; all 63 locatons were within a 50 m. stretch of shoreline.

Population Demography

358. In addition to being the largest snake species inhabiting Lake Conway (mean biomass=412.8 g., N=161) Nerodia cyclopion also was the most abundant (Table A2), thus this species dominated the ophidian fauna of the lake system. As reported elsewhere (Fitch 1981), green water snakes are sexually dimorphic in body size (Fig. 60). The mean SVL of sexable males (595.1 mm., N=57) was significantly shorter (X^2=39.39, P<.0001) than the mean for females (785.3 mm., N=87). The five longest males (720-770 mm. SVL) were considerably shorter than the five longest females (1,045-1,153 mm. SVL). These differences in body length also resulted in substantial sexual differences in biomass: the average female N. cyclopion (628.3 g., N=87) weighed 3.19 times as much as the average male (196.7 g., N=56), and the heaviest female (2,210 g.) weighed 4.96 times more than the heaviest male (446 g.).

359. Figure 60 shows that not only were the average body sizes of male and female N. cyclopion different, but that the frequency distribution of the two sexes varied as well. Whereas the distribution of females is skewed slightly to the right of the mean, males are skewed to the left. In addition, the male distribution is leptokurtotic (kurtosis=2.19) while that of females approaches normality (kurtosis=0.17). These differences appear to be most strongly related to the time required to reach sexual maturity and to the subsequent growth patterns of the sexes (see paragraph 375).

360. Comparisons of the mean body size (SVL) of Nerodia cyclopion from

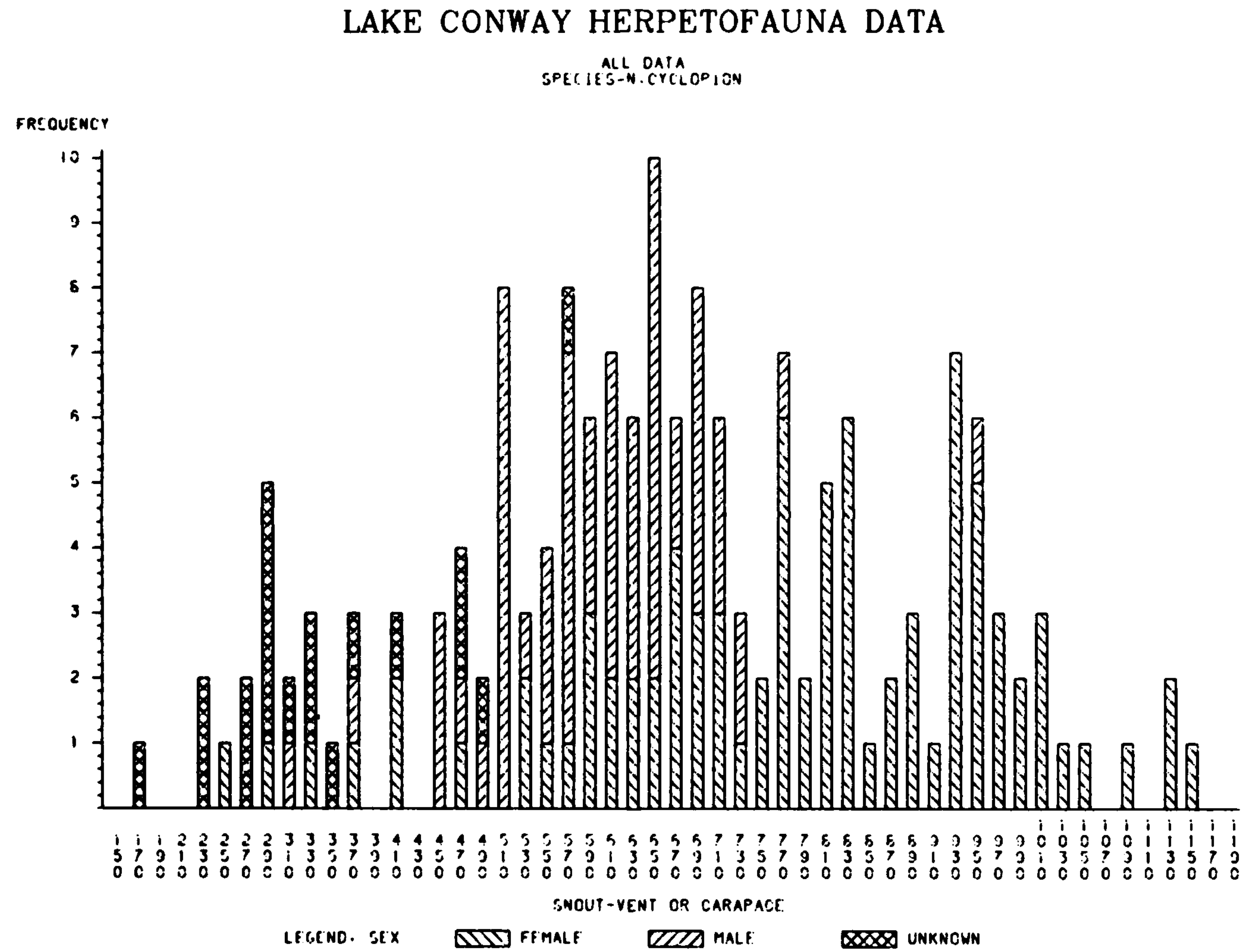

Figure 60. The size frequency distribution of Nerodia cyclopion on Lake Conway.

Lake Conway showed no statistically significant differences among pools (χ^2=3.81, P=.43) or among study years (χ^2=2.239, P=.30). Similar analyses performed separately for each sex also were insignificant (Kruskal-Wallis tests, P>.05). In addition, no significant pool or yearly differences were detected in the relative body mass or "condition factor" of N. cyclopion from Lake Conway (CANOVA F tests, P>.05).

361. In Lake Conway, the number of captured female N. cyclopion (N=85) outnumbered males (N=60) 1.42:1 (χ^2=4.31, P<.05) suggesting a biased sex ratio. However, the percentage of marked males (N=45) that was recaptured (4.44%) was less than that for females (11.48%, N=61), although the difference was not significant (χ^2=1.41, P>.65) perhaps because of small sample sizes. In addition, the larger size of females probably increased their conspicuousness, and thus the probability of detection by our field crews. For these reasons, we believe that the sex ratio of N. cyclopion on Lake Conway was not different from 1:1.

362. Table A4 and A5 respectively compare the mean relative density of snakes on permanent sites as measured by funnel-trap and herp-patrol captures. In marked contrast to herp-patrols where no significant differences were detected among the pools in any study year or for all study years combine (Table A5), funnel trapping produced signficant between-pool variation in densities in SY1, SY3, and for all years combined (Table A4). In addition, the relative density estimates provided by each of these sampling methods were not in rank-order agreement in any study year. Nor do the raw totals for each site (Table A3) provide much insight, since sampling effort varied. This was especially true for South Pool where 50 of 103 individuals were observed during shoreline censuses; this method produced only five specimens at the other study sites.

363. The low rank-order correspondence between the various sampling methods makes evaluation of N. cyclopion relative population densities on the permanent sites difficult. Most of this methodological variation appears attributable to differences in physical characteristics of the sites which, in turn, affected the relative success of each sampling method. For example, the broad, cattail-rimmed littoral zones present on the Middle and East Pool sites (see McDiarmid et al. 1983:10-18) prevented adequate sampling of this habitat

by herp-patrols. As a result, this method yielded few captures (Table A5) even though funnel traps demonstrated that N. cyclopion was relatively common within the littoral zones of these sites (Table A4). At other sites the littoral zone was much narrower and herp-patrols successfully sampled the snake populations. Because of the variability in the effectiveness of herp-patrols we suspect that funnel trapping provided the best means of accessing the relative densities of N. cyclopion among the sites, and that the rank-order of densities given in Table A4 is reasonably accurate.

364. South Pool was the only permanent site where recaptures (7 of 51 marked snakes) were adequate to evaluate absolute population size. At this site a Lincoln Index estimate of 120.0 N. cyclopion (2SE=69.5-450.5) was obtained for SY1 by using the formula N=MC/R where N= the population size, M= the number of snakes marked between June 1977 - October 1977, C= the total number captured between November 1977 - September 1978, and R= the number marked during the first time interval that were recaptured during the second interval (Tanner 1978). We believe that 120 N. cyclopion is a reasonable population estimate for this site during SY1: 57 different individuals were collected, 47 marked snakes were recaptured 15 times, and 25 individuals of unknown states eluded capture on the site during SY1. Assuming this estimate (120) is accurate and that snakes were restricted to the vegetated portion of the shoreline (460 m.), then the South Pool site supported a mean density of 0.26 N. cyclopion per linear metre of shoreline or 116.8 g. of snake biomass per linear metre (biomass/snake = 447.6 g.) during the first study year. Again, by assuming that the snakes largely were restricted to feeding in the first 20 m. of aquatic habitat (10 m. littoral zone, 10 m. open water, see paragraph 351) then the mean ecological density of N. cyclopion in the South Pool site was 130.43 snakes/ ha. and the average standing crop was 58.38 kg./ha. The higher trapping success on East Pool (Table A4) suggests that densities may have been even higher on this site.

365. These density and biomass estimates are among the highest reported for any snake species (for reviews, see Turner 1977 and Godley 1980). Even if both estimates are halved the same conclusion is reached: green water snakes were exceedingly abundant on the South Pool site during SY1. We suspect the reasons are threefold: (1) very little is known about the population demography

of snakes, especially in productive habitats (Turner 1977), (2) during SY1 the South Pool site seemed to have the proper prerequisites for this species, i.e., a long stretch of undisturbed Panicum - Fuirena shoreline with adjacent undeveloped uplands and dense populations of littoral zone forage fish, and (3) by the time our study had begun most of the remaining shoreline of South Pool had been developed (Williams et al. 1982), thus our permanent site represented the only refugia for this species on the pool. Presumably some of those individuals which survived shoreline development elsewhere also emigrated to our site, perhaps producing a localized concentration of snakes which subsequently was registered by us.

366. Tables A4 and A5 also provide yearly comparisons of the mean relative densities of Nerodia cyclopion on the permanent sites. In general, good yearly correspondence between herp-patrol and funnel-trap density estimates within each site was obtained. This finding was expected since the same sections of shoreline were sampled each year. The results generated by both sampling methods show distressing yearly decreases in the relative abundance of N. cyclopion on all permanent sites, especially between pre- and post-stocking years (Tables A4, A5).

367. Statistically, significant reductions in green water snake densities as measured by funnel-trap captures (Table A4) were obtained in South (χ^2=52.79, P<.0001), Middle (χ^2=11.58, P=.0032), and East Pool (χ^2=22.00, P<.0001), and for all pools combined (χ^2=77.29, P<.0001). In each of these comparisons snake densities were higher in SY1 than in the other two study years which were not different statistically from one another. No significant yearly differences were detected on herp-patrols (primarily because of the large number of trips when no snakes were seen; see McDiarmid et al. 1982, paragraph 133) but the results were similar: on all sites snake densities were substantially higher in SY1 than in SY2 or SY3 (Table A5).

368. The apparent causes of these reductions in snake density are complex, and varied with study site. On the South Pool site the total number of N. cyclopion sightings decreased from 98 in SY1 to 3 in SY2 to 2 in SY3 (Table A3). These incredible reductions largely were caused by destruction of the shoreline and adjacent uplands for housing, and by persecution from humans who almost uniformly believed that these water snakes were venomous

cottonmouth, Agkistrodon piscivorous. As mentioned earlier (paragraphs 355-356) on cool days in spring and fall, N. cyclopion typically basked on emergent vegetation and spent the winter in burrows of terrestrial mammals. Godley et al. (1981) reported that about 78% of the South Pool upland habitat was cleared with bulldozers during the winter and spring of 1977-78. We believe that a majority of the South Pool N. cyclopion population was killed as a result of these site preparation activities: only 16.5% (N=17) of our sample from this site was taken after April 1978. In mid-December 1977, a bulldozer operator reported killing four "cottonmouth" that were basking on shore; he believed that many more individuals were crushed. Our field crews found an additional ten dead N. cyclopion (one marked), all apparently killed by humans. In addition, our work contributed to some degree to the decline of this species on South Pool. Six snakes were known to have died as a result of our activities; four of these drowned in funnel traps.

369. The Middle Pool site also experienced significant reductions in the relative densities of N. cyclopion captured in funnel traps after SY1 (Table A4). This reduction was correlated with the bulldozing and draglining of 60.0% of this site in April 1978 (Godley et al. 1981:16). None of the snakes collected on this site was known to have died as the result of our sampling program. Thus, we conclude that habitat destruction was the major cause of declines in N. cyclopion on this site.

370. The three other sites also showed substantial reductions in Nerodia cyclopion densities during the study (Tables A3-A5). Families of river otter (Lutra canadensis), known predators of aquatic snakes (Godley 1982), habitually raided our East and West Pool trap lines after SY1 (see paragraph 52). Thus, we suspect that otters ate most snakes captured in traps in these pools in SY2 and SY3. Only four of 61 N. cyclopion registered from these two sites (Table A3) were known to have died as a result of our field work. All drowned in funnel traps. The Gatlin Canal site was bordered on both sides by homes. Again, we suspect that humans killed most snakes that were encountered. Shoreline development on adjoining section of West Pool and Lake Gatlin probably contributed to this decline by removing a major source pool of snakes.

371. In summary, man appears to be the greatest threat to Nerodia cyclopion populations on Lake Conway. The available evidence indicates that

this snake is extremely intolerant of habitat modification and disturbance, and cannot survive on the beach habitats that now characterize most of the lake system. Of all the herpetofaunal species of Lake Conway, N. cyclopion experienced the greatest proportional reduction in numbers (Table A2) and probably is in grave danger of extirpation. Because of these trends, we predict that this species will be absent from South Pool within five years, and may be restricted to the East Pool islands within the next decade.

Food Habits

372. The stomach contents of 11 preserved Nerodia cyclopion from Lake Conway were examined. Most of the individuals had drowned in funnel traps, and only three contained food other than trap bait. All three had the remains of digested fish, and one also contained the tail of a purple fishing worm in its gut. Five live individuals regurgitated fish upon capture (principally centrarchids and poeciliids), and one regurgitated a Siren lacertina. In Louisiana 95% of the volume of food ingested by N. cyclopion was fish (Mushinsky and Hebrard 1977a). We suspect that this snake species is primarily piscivorous in Lake Conway as well.

Growth and Reproduction

373. Relatively little is known about growth and reproduction in Nerodia cyclopion from Lake Conway, or from elsewhere in its range (for reviews see Wright and Wright 1957, Fitch 1970, Kofron 1979). Mating typically occurs in spring. In Florida populations of N. cyclopion, parturition occurs from June through September; newborns range in mm. SVL from 188 to 275 with 225 being an average length (Wright and Wright 1957, D. Franz pers. comm.). Most mature females appear to be on an annual cycle and clutch size (7-101) is positively correlated with female body size (Wright and Wright 1957, Kofron 1979).

374. On Lake Conway distinct year classes are difficult to discern from monthly scattergrams (Fig. 61). In our sample of 170 measured individuals, the smallest juveniles (222-224 mm. SVL) were collected in early August. By the end of September these newborns averaged about 325 mm. SVL (range = 270-403 mm.); the higher variance probably is caused by individual differences in birth dates and growth rates. The minimum size of individuals collected in the following year suggests that growth rates are rapid, at least from late March through September.

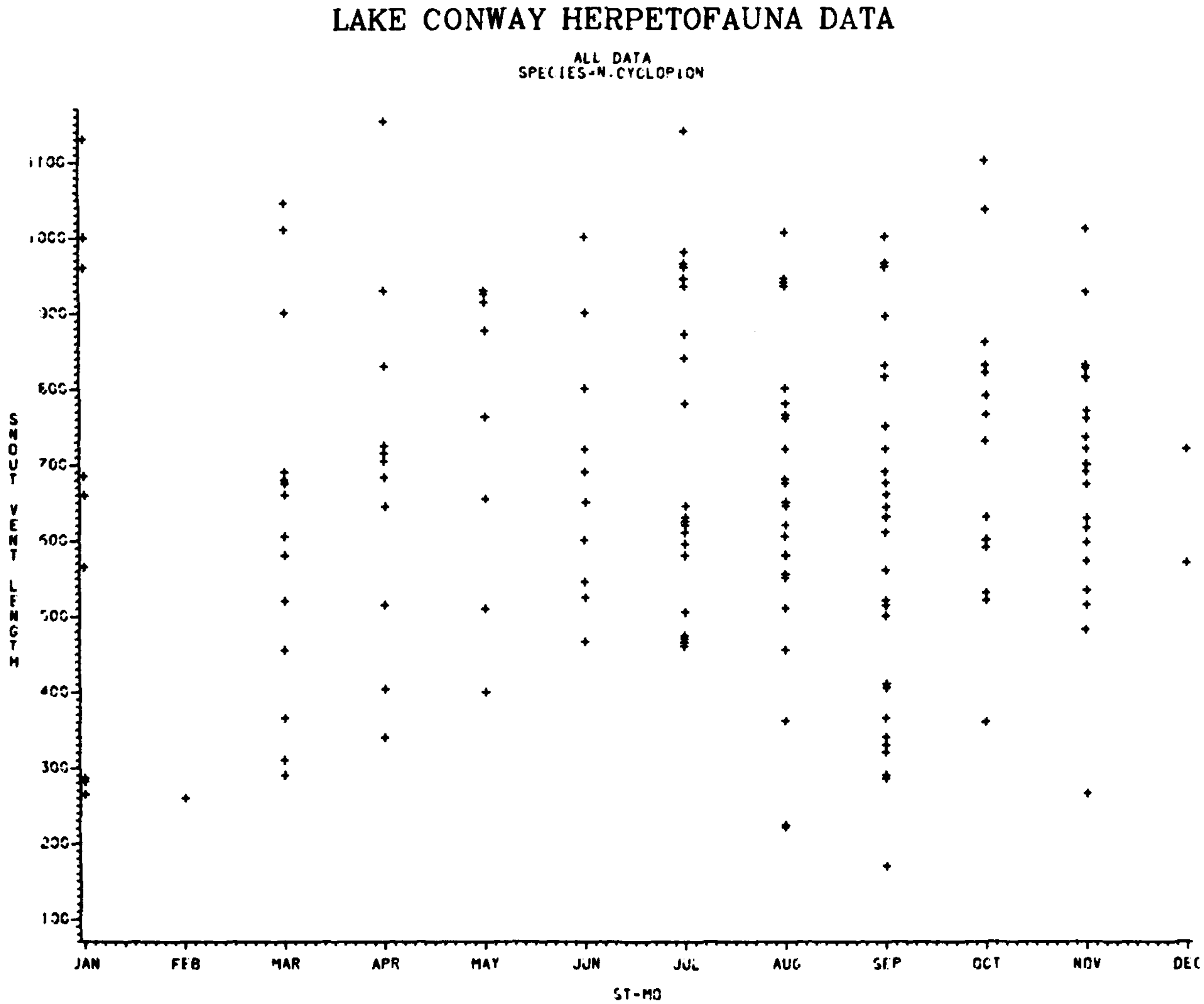

Figure 61. Monthly size distribution of Nerodia cyclopion from Lake Conway.

375. On Paynes Prairie, Alachua Co., Florida, N. cyclopion average at the end of their first and second respective years about 550 and 700 mm. SVL (D. Franz, pers. comm.). Thereafter, individual and sexual differences in growth make determinations of age classes difficult. These growth trajectories probably are similar to those of N. cyclopion from Lake Conway (Fig. 61) and suggest that annual growth rates average about 325 and 150 mm. SVL in the first and second year, respectively. The sex, initial SVL, days between captures, and annual growth rates of three N. cyclopion recaptured more than 90 days apart during the major growing season (April-September) on Lake Conway were as follows: female, 840 mm., 286 days, 114 mm./yr.; female, 925 mm., 91 days, 81 mm./yr.; male, 520 mm., 338 days, 118 mm./yr. These limited recapture data suggest that larger individuals may grow between 80 and 120 mm. SVL per year. On the basis of D. Franz's large sample of necropsied N. cyclopion, the minimum average size at sexual maturity is about 700 mm. SVL for females and 550 mm. SVL for males. From this information we believe that male N. cyclopion typically mature in about 1.5 years with females delaying reproduction until 2.5 years of age. Some females may mature a year earlier or later.

Nerodia fasciata (Florida watersnake)

Distribution and Habitat Preferences

376. Nerodia fasciata was the second most abundant snake on Lake Conway with 46 observations; of these, 38 were collected. The distribution of individuals by pool includes eight from South, 12 from Middle, one from East, three from West Pool, and 22 from Lake Gatlin (Table A2). Herp-patrol (N=27), shoreline census (11), and funnel traps (7) accounted for 45 of the 46 sightings (Table A1).

377. Although sample sizes were small, N. fasciata appears to use a wide variety of habitats on Lake Conway. Of 26 specimens for which habitat information was available, six were encountered on shore, 15 in the littoral zone, and five in open water. In addition to occurring in all native littoral zone habitats, N. fasciata also was tolerant of the presence and activities of man. Florida water snakes were the only snakes regularly encountered on white sand beaches and often were found in second growth, disturbed habitats. For

example, the highest relative densities of *N. fasciata* on permanent sites occurred in Gatlin Canal (Table A3) which was bordered on both sides by homes (McDiarmid et al. 1983). Hebrard and Mushinsky (1978) also found that *N. fasciata* used the widest variety of microhabitats of five sympatric natracine species in Louisiana.

Activity Patterns

378. *Nerodia fasciata* was observed on Lake Conway in all months except December and January. If all four study years are combined a significant difference in seasonal activity is suggested (χ^2=7.60, P=.067) with three observed in winter, 19 in spring, 15 in summer, and 13 in fall. Mushinsky and Hebrard (1977b) found a similar pattern of seasonal abundance for *N. fasciata* in Louisiana, and reported that *N. fasciata* was principally diurnal in activity but shifted to nocturnal habits during the hottest summer months. This trend also was evident in the Lake Conway population.

Population Demography

379. Figure 62 shows the size frequency distribution of 35 *N. fasciata* measured on Lake Conway. As is typical of all other natracine snakes (Fitch 1981), females are larger in body size than males. The mean SVL of 13 adult females was 677.9 mm. (range=412-830 mm.); 12 adult males averaged 408.91 mm. SVL (325-765 mm.). No significant difference occurred in the mean SVL of *N. fasciata* between pools (χ^2=0.16, P=0.92).

380. Of the 29 *N. fasciata* marked and released on Lake Conway, none was recaptured. Thus no direct estimate of population density could be obtained. Based on the total number of observations for the two *Nerodia* spp. on Lake Conway, *N. fasciata* (N=46) was about 1/5 as common as *N. cyclopion* (N=233). However, this proportion is suspect because (1) 14.3% of 119 marked *N. cyclopion* were recaptured, and (2) the relative efficiency of the major herpetofaunal sampling methods was not equal for the two species (χ^2=7.94, P<.05; Table A1).

381. Probably because of the relatively low absolute abundance of *N. fasciata* on the permanent shoreline sites, no significant differences in capture rates on herp-patrols or in funnel traps were detected either between years or between pools (Kruskal-Wallis tests, P>.05). However, *Nerodia fasciata* and its only congener on Lake Conway, *N. cyclopion*, provided an

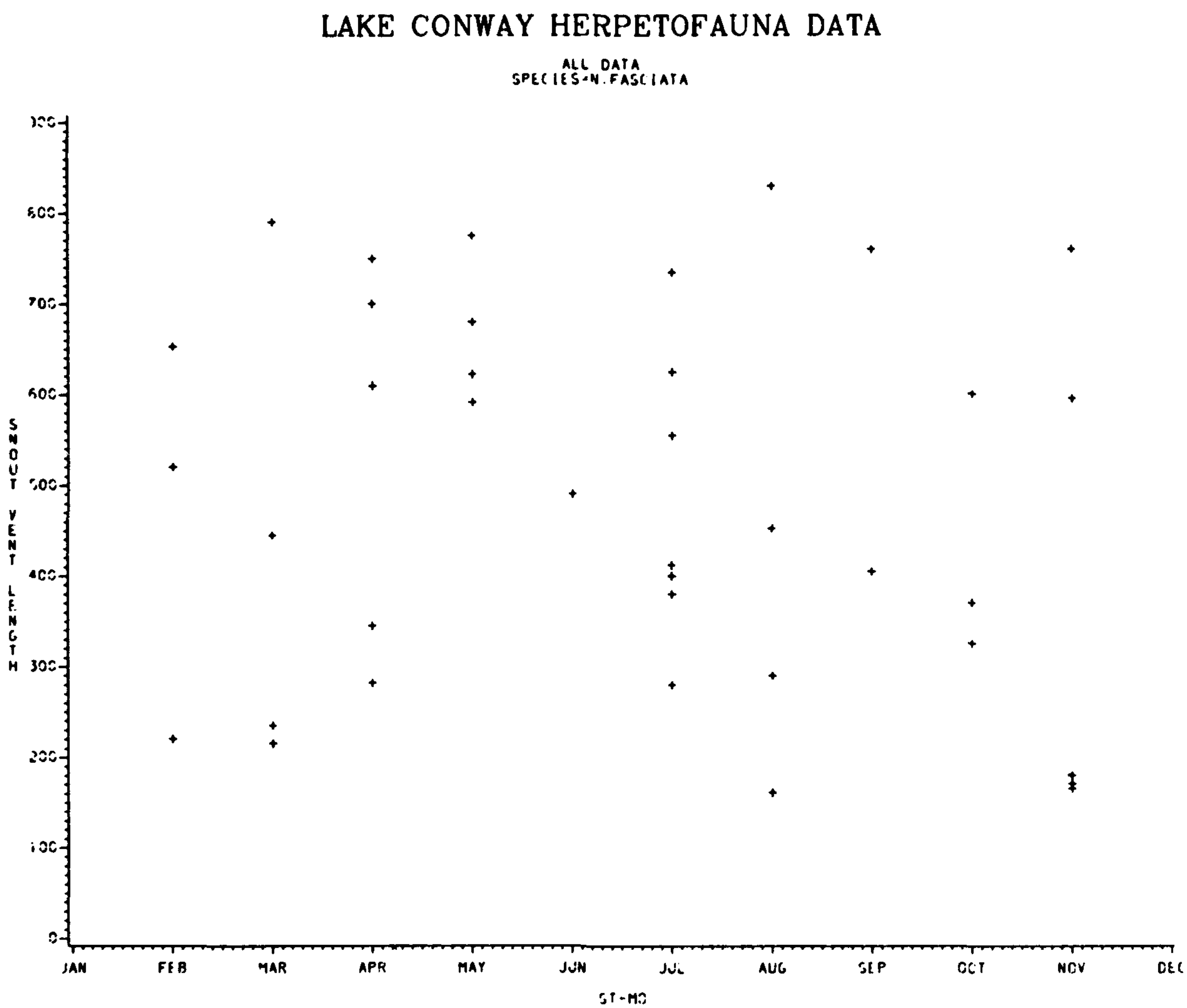

Figure 62. Monthly size distribution of Nerodia fasciata from Lake Conway.

interesting contrast in occurrence on the permanent shoreline sites and in temporal responses to changes in these sites during the study. If all observations on permanent sites are summed (Table 40), the two species of water snakes show different relative density responses to these sites (χ^2=51.06, P<.001). The disturbed Gatlin Canal site contributes most to chi-square with the relative abundance of N. fasciata much higher than expected and N. cyclopion lower than expected. In addition, on three initially undisturbed sites (South, Middle, and East Pools, see below), the relative abundance of N. fasciata was lower than expected.

382. The relative abundance of the two Nerodia spp. also changed significantly (χ^2=21.05, P<.001) with study year (Table 41). The expected relative abundance of N. cyclopion was higher in SY1 and that of N. fasciata higher in SY2. Inspection of yearly total observations on the permanent sites (Table A3) and a review of changes in the permanent sites (McDiarmid et al. 1983) suggest that the two snake species responded differentially to disturbance by man. Whereas N. cyclopion virtually was eliminated by human habitat destruction on the South Pool, Middle Pool, and Gatlin Canal sites, N. fasciata persisted.

Food Habits

383. Little is known about the foraging ecology of N. fasciata on Lake Conway. One adult female captured on shore had eaten an adult toad (Bufo terrestris) and several individuals taken in funnel traps regurgitated cut fish bait or minnows (especially Gambusia affinis, the most frequently trapped fish). In a Louisiana swamp, G. affinis was the most frequently ingested prey of N. fasciata but adult snakes also consumed frogs and toads (Mushinsky and Hebrard 1977a).

Reproduction and Growth

384. Only one reproductive female N. fasciata was collected on Lake Conway. This female (760 mm. SVL, 613 g.) gave birth to 22 young ($\bar{X}$ SVL=15.4 mm.) on 13 October 1978 in the laboratory. The latest previously reported birth date for this species in Florida was 2 August (Fitch 1970). Litter size in this species is known to range from 9 to 57 (Fitch 1970, Kofron 1979).

385. The plot of N. fasciata SVL by months suggests tentatively that three year classes can be recognized (Fig. 62). Juveniles born in late summer

Table 40

Chi-square analysis of the distribution of two water snake species on permanent shoreline sites summed over all years.

	South Pool	Middle Pool	East Pool	West Pool	Gatlin Canal	Total
Nerodia fasciata						
Observed	7	4	1	3	22	37
Expected	17.25	2.35	7.06	3.14	7.21	
Chi-square	6.09	1.16	5.20	0.01	30.33	
Nerodia cyclopion						
Observed	103	11	44	17	24	199
Expected	92.75	12.65	37.94	16.86	38.79	
Chi-square	1.11	0.22	0.9	0.33	5.64	

Table 41

Chi-square analysis of the distribution of two water snake species on permanent shoreline sites by study year.

	SY1	SY2	SY3	Total
Nerodia fasciata				
Observed	19	11	7	37
Expected	28.06	4.70	4.23	
Chi-square	2.92	8.44	1.81	
Nerodia cyclopion				
Observed	160	19	20	199
Expected	131.94	25.30	22.77	
Chi-square	5.97	1.57	0.34	

or fall probably grow to 300-450 mm. SVL by the following fall, and by the end of their second year may exceed 550 mm. SVL. Most males probably attain sexual maturity in spring at 15-18 months of age (350-450 mm. SVL) with most females maturing the following spring (27-31 months) at a SVL of 500-600 mm. This interpretation is consistent with what is known of the closely related species *N. sipedon* from Missouri (Bauman and Metter 1977) and *N. fasciata* in other parts of Florida (D. Franz, pers. comm.).

Regina alleni (Striped swamp snake)

386. Several *Regina alleni* were collected on Lake Conway; three from the South Pool permanent site and four from the Middle Pool site (Table A3). Funnel traps and shoreline censuses produced all specimens of this secretive snake (Table A1). Specimens were taken in panic grass (*Panicum hemitomon*), waterhyacinth (*Eichhornia crassipes*), cattail (*Typha latifolia*), pickerelweed (*Pontederia lanceolata*), and lake rush (*Fuirena scirpoides*). Striped swamp snakes probably occurred in all pools in areas of dense littoral zone vegetation.

387. Little is known about the demography of *R. alleni* on Lake Conway. In some Florida waterhyacinth communities the species may be very abundant, reaching densities of 1,287 per hectare (Godley 1980). Two of the seven *R. alleni* taken on Lake Conway were found dead: one fresh specimen was found partially eaten in the same funnel trap with a live adult *Siren lacertina*; the other was found on shore apparently killed by a raccoon (*Procyon lotor*). Godley (1982) reviewed aspects of predation on this species.

388. Striped swamp snakes have a very restricted diet. Adults eat crayfish almost exclusively, while juveniles feed upon smaller crayfish, grass shrimp, and odonate naiads (Godley 1980). Females probably mature in two years and produce from two to 34 young.

Thamnophis sauritus (Peninsula ribbon snake)

389. Ribbon snakes were encountered only in two pools on the permanent shoreline sites during SY1 (Tables A2 and A3). Five individuals were collected

on the undisturbed marsh section of the Middle Pool site; three in a drift fence and two during shoreline censuses. One individual was seen during a shoreline census of the East Pool site. At both sites, *T. sauritus* was found in marshes composed of cattail (*Typha latifolia*) and pickerelweed (*Pontederia lanceolata*). All were adult snakes.

390. Rossman (1963, 1970) in his reviews of the biology of ribbon snakes, reported that sexual maturity is attained at between two and three years of age. Brood size for 12 Florida females averaged 15.8. The diet consists chiefly of fishes, and larval and adult amphibians.

Thamnophis sirtalis (Eastern garter snake)

391. Only two garter snakes were encountered during the study. An adult male and female were collected lying beside each other under a log 10 m. up on the shore of the South Pool permanent site on 1 March 1978. Development of the South Pool shoreline (McDiarmid et al. 1983) probably extirpated garter snakes from this site. However, the species is likely to occur in other undeveloped sections of Lake Conway.

392. Although not as aquatic as its congener *T. sauritus* (Carpenter 1952), garter snakes feed extensively on frogs and toads and are thus dependent upon a functional lake system for survival. *T. sirtalis* attains sexual maturity in two to three years and adult females produce broods ranging in size from seven to 25 (Fitch 1970).

PART V: DISCUSSION AND CONCLUSIONS

393. The accounts presented in this report have summarized our knowledge of the natural history of the 30 species of amphibians and reptiles known from Lake Conway. The accounts focused on two major objectives of the Lake Conway herpetofaunal project, namely to identify spatial and temporal changes in life history parameters of the component species, and to determine whether any observed changes were the result of the white amur aquatic plant control program. Although these objectives were of primary importance, it was clear from the outset of the project that a number of additional, confounding factors were influencing the ecological organization of the Lake Conway herpetofauna. These factors also are addressed to properly evaluate the effects of the LSOMT.

394. The following discussion serves two major functions: (1) to summarize from the species accounts all detected ecological changes together with their presumed causative agents into a cause-effect matrix for the Lake Conway herpetofauna, and (2) to evaluate systematically the relative effects of the LSOMT and other environmental perturbations on the herpetofaunal community of Lake Conway.

The Community Matrix

395. Appendix B of this report provides for each amphibian and reptile species of Lake Conway the following information: (1) an enumeration of those ecological parameters that showed statistically significant or biologically meaningful yearly changes during the study, (2) an assessment of the causative agent(s) believed to be responsible for the particular ecological shift, and (3) a listing of the critical life history traits that may be important in understanding what makes a species especially vulnerable to specific kinds of ecological disturbance. Hopefully, evaluation of these traits can be used elsewhere to predict the outcome of similar disturbance phenomena in other aquatic herpetofaunal communities. The assignment of values for each of these categories was based on information provided in the species accounts.

396. It is clear from the species accounts and from Appendix B that some level of subjective evaluation was necessary for both the measurement of ecological change and for an assessment of causative agents. Several examples will illustrate this point. On the permanent sites three species of very

common frogs (_Hyla cinerea_, _Rana grylio_, _R. utricularia_) showed statistically significant fluctuations in density (Tables A4-A6). Two other frog species (_Hyla femoralis_ and _H. squirella_) were known only from a few individuals in a single pool (Table A3). Neither of these latter species showed a statistically significant change in density yet extensive field work indicated that both species were extirpated from the Conway system during the study period. Exclusion of these latter two frogs from a list of herpetofaunal species that experienced a "significant" ecological change would ignore meaningful data. To acknowledge these situations, we established in Appendix B two criteria for the detection and measurement of a change in an ecological parameter (statistically significant, biologically meaningful). The "biologically meaningful" category only includes those measured responses in which no statistical differences were detected (or no statistical tests run) but in which the ecological trends were very clear. Our use of this category was conservative.

397. Once a significant or biologically meaningful change in an ecological parameter has been identified, what rational procedure best characterizes and isolates the causative agent(s)? Often no statistical solution to this problem exists. Under the constraints of the LSOMT, several identified causative agents often were operating simultaneously without the potential for controlling important variables. Fortunately, the presence or relative effects of the causal agents often varied among pools. This variation provided a partial control of confounding variables and permitted a more objective evaluation. For example, shoreline development only occurred on two of the five permanent sites (South and Middle Pool) during the study. Similarily, the response of the macrophyte communities to herbivory by white amur varied considerably among the pools (Schardt et al. 1981). Thus, the relative importance of these factors could be evaluated by examining differential responses of the herpetofaunal species among the pools. In species where several causative factors apparently were operating simultaneously to produce a significant response, we chose the most direct and parsimonious explanation to account for the observed change. In those cases where two or more factors clearly were responsible for a given change, each factor was assigned a major or minor role based on the available evidence. This assignment of factor "levels" did not alter the pattern of response, but

did allow for a more detailed analysis of the cause-effect relationships.

Responses of the Herpetofaunal Community

398. For the herpetofaunal community of Lake Conway, Table 42 summarizes the number of species that showed yearly variation in any of nine ecological parameters, and assesses the causes of these shifts. Ten of the 30 species known from Lake Conway showed statistically significant yearly changes in at least one parameter. An additional eight species were judged to have experienced a biologically meaningful shift in at least one parameter; in four of these latter species a statistical effect also was detected (Table 42, Appendix B).

399. The distribution of detected ecological shifts varied with both the measured parameter and with the taxonomic group (Table 42, Appendix B). Of those species in which yearly variation was observed, most showed a change in relative density (N=15), followed by seasonal activity (6), population structure (5), open water habitat use (4), food habits (4), and movement patterns (1). No yearly variation was detected in littoral zone habitat use (i.e., the types of habitats occupied in each year), growth rates, or reproduction (i.e., mean reproductive output per individual).

400. We suspect that the distribution of detectable shifts reflects both the ease of measuring the change (i.e., sample size dependence and the sensitivity of the statistical test used for each parameter) and the relative vulnerability of a species to environmental disturbance. For example, we believe that more species showed a change in relative density than in any other parameter for the following reasons:

i. Several sampling methods (i.e., herp-patrol and funnel traps) and statistical tests (Kruskal-Wallis and difference among proportions tests) were available for detecting variation in density. Changes in most other ecological parameters were monitored by only a single method and test.

ii. Our census techniques did not require capturing individuals for inclusion in the density estimate, thus for most species sample sizes were much greater for density than for any other parameter. To illustrate, 199 of the 233 Nerodia cyclopion were collected on the permanent sites and included in the density estimates, but

Table 42

Summary of the number of herpetofaunal species showing statistically significant or biologically meaningful (in parentheses) yearly changes in nine ecological parameters measured on Lake Conway, and an assessment of the causative agents. Litt = littoral, O.W. = open water, Seas. = seasonality, Move. = movement, Repro. = reproduction.

	Habitat		Activity		Demography					Species
	Litt.	O.W.	Seas.	Move.	Structure	Density	Food	Growth	Repro.	total
WHITE AMUR EFFECTS		4			1	3	1(2)			4(1)
HUMAN EFFECTS										
Shoreline development					1(1)	9(5)				9(5)
Destruction/removal					1(1)	1(1)				1(1)
Boat mortality					1(1)	2(1)				2(1)
Investigators				1	2	4				4
NATURAL EFFECTS										
Water level					1	3(2)				3(2)
Weather			(6)							(6)
Density							1			1
UNKNOWN					3	2				4
Species Total		4	(6)	1	4(1)	10(5)	2(2)			

only 163 were captured and used in the population size structure analysis, and only 11 specimens were taken for food habits or reproductive analyses. Similarly, density estimates were available for the eight species of anurans on Lake Conway, which represented 26.7% of the species' total and 46.0% of the total herpetofaunal observations. However, because frogs generally were not captured, marked, or taken for destructive samples, only yearly variation in seasonal activity and relative density could be measured in this numerically important component of the herpetofaunal community. The season of peak calling activity varied among study years in five of the eight anuran species. Three species showed statistically significant differences in relative density; two other rare species apparently were extirpated from the lake system (Appendix B).

iii. Probably the most common and immediate response of all species to environmental disturbance (e.g., shoreline development, macrophyte removal) was a reduction in the numbers of individuals present. Of the 13 species showing a detectable density change (Appendix B), nine decreased in abundance, two increased, and one fluctuated. All of the amphibian and reptile species on the lake were dependent upon a vegetated littoral zone during some period of their life cycle. As a result, conversion of this vital habitat to beach-front property lowered the total carrying capacity of the environment. In this sense, Table 42 and Appendix B greatly underestimate the density response of the fauna; we suspect that fewer individuals of all species are present on the lake system now than during SY1 when more high-quality shoreline habitat was available. The same may be true of species inhabiting open-water zones.

401. A change in population size (age) structure was detected in five species, all of which also showed a negative density response (Table 42, Appendix B). The change in size structure in these five species, regardless of the causative agents, was associated with differential annual variation in survivorship of some sex or size (age) class. Excluding anurans, it was not a

coincidence that these same species were the only ones on Lake Conway to exhibit statistically significant intraspecific differences in habitat use. We suggest that the detected changes in population structure were the result of a common response (density reduction of one sex or age category) in each species to environmental disturbance.

402. Among the two measured activity parameters (Table 42, Appendix B), five species of common frogs and one turtle (Sternotherus odoratus) exhibited distinct yearly shifts in seasonal activity patterns. S. odoratus also was the only species to show annual variation in the mean distance moved between captures. For both activity parameters, these taxa typically had the largest sample sizes among the species sampled (Appendix B). No interactions between yearly changes in activity patterns and any other ecological parameters were noted.

403. Statistically significant yearly shifts in the types of open water habitats occupied by one salamander and three turtle species were detected. No yearly changes were found in the types of littoral zone habitats used by any herpetofaunal species (Table 42, Appendix B). The apparent differential herpetofaunal response to these two structurally and taxonomically distinct plant associations is interesting from several viewpoints. Both open water (Schardt et al. 1981) and littoral zone (McDiarmid et al. 1983) plant associations changed in species composition and abundance patterns during the study. Thus, the opportunity to show either a passive (i.e., remain at same site even if plant species composition changes) or an active (i.e., move to new location to remain in same plant association) shift in habitat utilization patterns was available in both plant associations. In addition, both habitats supported rather distinct herpetofaunal communities, i.e., most of the amphibian and reptile species of Lake Conway showed clear preferences for one or the other association (Appendix B).

404. We suspect that open water species as a group are more generalized (i.e., less habitat specific) and typically respond passively to habitat modification, whereas littoral zone species are more habitat specific, actively seeking out the appropriate habitat if available. Compared with most littoral zone species, open water forms tend to be larger in body size (Appendix B) and more mobile. Extensive radiotelemetry work indicates that

even among comparable-sized species pairs (Amphiuma means and Siren lacertina, Pseudemys floridana and P. nelsoni, Kinosternon subrubrum and Sternotherus odoratus) open water forms (S. lacertina, P. floridana, S. odoratus) have much larger home ranges and occupy a wider range of habitats.

405. On Lake Conway, yearly shifts in the foraging ecology of two carnivorous species (Amphiuma means, Sternotherus odoratus) were detected, and strongly suspected in two herbivores (Pseudemys floridana, P. nelsoni) based on their food preferences as determined by laboratory experiments and changes in macrophyte community structure. No annual variation in growth rates or reproduction was detected in any species, possibly because of small sample sizes and associated high variances among individuals and among pools.

406. To summarize, 17 (56.7%) of the herpetofaunal species of Lake Conway showed statistically significant or biologically meaningful yearly variation in at least one of nine measured ecological parameters. The frequency of occurrence of these shifts varied with both the ecological parameter and the taxonomic group. Ecological changes were detected in two of four salamanders, all eight frogs, the American alligator, five of ten turtles, and one of seven snakes.

Causes of the Ecological Shifts

407. Having established that major components of the herpetofaunal community of Lake Conway experienced detectable changes in ecology during the study we now examine the presumed causes of these shifts. Our primary objective will be to evaluate systematically the relative effects of the white amur aquatic plant control program and other environmental perturbations on the amphibian and reptile populations of Lake Conway.

408. In Table 42 and Appendix B we have grouped the nine identified causative agents into four general categories: the effects of the white amur, human disturbance, natural phenomena, and unknown causes. Under the category of human disturbance we include the effects of shoreline development, destruction/removal (killing or removing individuals from the lake system), boat mortality, and investigator influences. This latter factor takes into account such effects as mortality caused by our trapping (drowning or river otter predation) and marking procedures, trap shyness, and home range shifts as a result of repeated captures. Natural phenomena include yearly fluctuations

in water level, seasonal weather conditions, or density effects (see paragraph 412). For some ecological parameters the cause of a shift was unknown, and these are noted accordingly.

409. Of all the identified causative agents, human disturbance in one form or another was responsible for more ecological shifts in more species than any other major category. As mentioned previously (paragraph 400), shoreline development probably caused a reduction in the density of all herpetofaunal species on Lake Conway, although distinct reductions in numbers were demonstrated in only 14 species (Table 42). Removal of this vital habitat also was suspected to have caused shifts in the population structure of two species. Because shoreline development on Lake Conway shows no signs of abatement, we expect that this trend will continue, resulting in the extirpation of species in addition to Hyla femoralis and H. squirella from the lake system. The destruction or removal of alligators and green watersnakes was known to have caused a major density reduction in these species and probably affected other snake and turtle species as well.

410. The urbanization of Lake Conway also has resulted in an increase in recreational use of the lake, especially by the boating public. For the eight herpetofaunal species that regularly frequent open water environments (Appendix B) strikes from boat propellers probably represent a serious threat to their continued existence. All of these species are potentially long-lived animals. Evolutionarily, they have countered high, natural egg and juvenile mortality with an expected long adult lifespan and repeated reproductive attempts. For some of these species (e.g., Pseudemys floridana) juvenile recruitment seems inadequate to replace adult mortality from boat propeller strikes alone and these species are experiencing serious, and perhaps irreversible, population declines on Lake Conway.

411. We believe that our sampling program was partially responsible for yearly shifts in the population structure of two species (Amphiuma means and Sternotherus odoratus), and in the density of these species in addition to two other forms (Siren lacertina and Nerodia cyclopion) (Appendix B, Table 42). Trap mortality by drowning and by river otter predation, marking mortality, and behavioral responses (e.g., trap shyness, home range shifts) to repeated captures were contributing factors. The relative importance of our impact on

the herpetofauna was difficult to determine, but certainly varied with the species and the ecological parameter in question.

412. The influence of "natural" factors also affected aspects of the biology of some species. Five species of frogs and one turtle exhibited distinct yearly shifts in seasonal activity (Appendix B, Table 42); all apparently in response to annual variation in seasonal weather conditions. In the category of natural factors we included fluctuations in water level, even through human manipulation of water level on Lake Conway through control structures and pumping of the lake and underlying aquifer modified the influence of rainfall. Aerial photographs and water level data supplied by the U. S. Geological Survey indicated a marked decline in the water level of Lake Conway since 1976. For example, the minimum water level for the 15-year period 1962-1976 averaged 85.44 feet above mean sea level and never dropped below 84.30 feet; during our study the minimum water level was above 84 feet only in 1980. Thus, relatively high water conditions preceded the study, followed by low water during the LSOMT. An important but unmeasured consequence of water level fluctuation was a reduction in the quantity and quality of littoral zone habitat on the lake system. Such changes probably affected all species to some degree. The high densities of many species recorded in SY1 relative to SY2 and SY3 may have been caused in part by contraction of the available habitat resulting in a short-term concentration of animals. For example, aerial photographs taken in 1974 clearly showed that the East Pool "islands" actually were extensive marshes with numerous criss-crossing alligator trails; presumably many other aquatic species occupied these areas as well. However, by the time our study began (1977) most of this habitat was dry land, and remained so through the study. Finally, we attribute the improved feeding success of Amphiuma means in SY2 and SY3 relative to SY1 to low densities in later years, which may have resulted in a decrease in intraspecific competition. We consider this to represent an higher order interaction (see paragraph 58).

413. Four species experienced a shift in at least one ecological parameter in which the causative agent was not identified (Table 42, Appendix B). In certain of these cases (e.g., population structure response of Siren lacertina, density response of Chelydra serpentina) we suspect that the

obtained results were statistical artifacts of the numerous comparisons made, i.e., at the 95% confidence level 5% of the comparisons are expected to show a significant difference even if no difference existed (Steel and Torrie 1960). In other cases, the significance levels were much higher ($P<.0001$) and several causative agents were identified. However, none of these alone or together seemed sufficient to produce the measured response.

414. To recapitulate, we identified eight major confounding factors in operation during the LSOMT; others probably were present. The relative effects of each of these factors varied with the species, pool, study year, and ecological parameter. These causative agents were at least partially responsible for many of the temporal ecological shifts detected in the Conway system. From this standpoint, the choice of Lake Conway as a test lake was unfortunate. Realizing these limitations, we now examine the effects of white amur on the herpetofauna of Lake Conway.

415. Appendix B and Table 42 indicate that one salamander and three turtle species showed distinct changes in at least one ecological parameter that was attributable, directly or indirectly, to the introduction of white amur into Lake Conway. All of these species showed significant shifts in the types of open water habitats occupied during the study. In general, as white amur removed most of the near-shore populations of *Potamogeton illinoensis* (Schardt et al. 1981), a greater proportion of individuals of these four species were found over beds of *Vallisneria americana* and *Nitella megacarpa*, or over substrate devoid of vegetation. The responses of these species to alterations in the macrophyte community varied. The salamander *Siren lacertina* and the turtle *Kinosternon subrubrum* moved to habitats dominated by other plant species, rarely frequenting bare bottom, open water habitats. In contrast, two other turtle species (*Pseudemys floridana* and *Sternotherus odoratus*) increased their use of bare bottom habitats in addition to shifting to alternate plant species. Because changes in habitat use were correlated with changes in macrophyte populations as a result of white amur (Schardt et al. 1981), and because no other causative agent directly affected these aquatic plants, we conclude that herbivory by white amur was the primary cause of the observed shifts in habitat use. Other herpetofaunal species which occupied open water environments also may have been affected, but in these cases sample sizes were

too small to detect a change even if one occurred. No noticeable changes in littoral zone plant species composition or abundance as a result of white amur were observed on Lake Conway; hence we believe that the fish had little or no effect on the species restricted to this habitat.

416. The white amur was implicated as contributing significantly to a yearly shift in the population structure of one turtle species, Pseudemys floridana (Appendix B, Table 42). As discussed in the species account (paragraphs 195-212), destruction of littoral zone habitat and mortality from boats were primarily responsible for this shift. However, by eliminating most of the extensive beds of Potamogeton illinoensis in the lake system, white amur removed an important habitat for juvenile P. floridana and contributed to the differential decline of this size class.

417. In the three species where white amur was suspected of causing a decline in density, additional confounding factors usually were operating as well (Appendix B). For the chiefly open-water turtle species, Pseudemys floridana and Sternotherus odoratus, habitat loss, investigator effects, and boat mortality contributed to reductions in population density to some degree. However, the reluctance of these turtles and especially of the salamander Siren lacertina to occupy open water habitats that were devoid of vegetation, and the clear field evidence that lake bottom supporting vegetation had higher animal densities of each of these species than did barren bottom suggest that white amur played a major role in their decline.

418. The available evidence also suggests that white amur affected the foraging ecology of at least three species. Macrophyte removal by white amur indirectly affected the diet of the carnivorous turtle Sternotherus odoratus by changing the distribution and abundance of its snail and insect prey, which were dependent upon these plants. On the basis of controlled food preference experiments with the two herbivorous turtle species on Lake Conway (Pseudemys floridana and P. nelsoni; paragraphs 213-220, 248-250), and knowledge of change in plant community structure as a result of white amur (Schardt et al. 1981), we conclude that these turtles were in direct competition for specific macrophyte species on Lake Conway, especially Hydrilla verticillata. The potential consequences of this competitive interaction are numerous (see paragraph 220) but very difficult to detect and quantify.

419. Given that both Pseudemys floridana and P. nelsoni are large (to 5.7 kg.), relatively common species capable of consuming 12 to 18% of their body mass per day in plant material, why haven't these native herbivores "controlled" the macrophyte populations of Lake Conway without the aid of white amur? Questioning of long-time residents of the lake revealed two relevant observations: (1) aquatic macrophytes are a relatively recent problem, and (2) the number of emydid turtles has decreased considerably in recent years. Blancher and Fellows (1979) detailed the ways in which urbanization has caused a tremendous increase in the nutrient loading of Lake Conway, one symptom being a virtual explosion of aquatic plant populations. Our work has shown that even during a three-year period the abundance of emydid turtles declined dramatically on the lake system, largely as a result of urbanization (e.g., shoreline development, boat propeller mortality). Although it is unknown if emydid turtles truely limited macrophyte populations on Lake Conway during more pristine times, it is clear that recent populations of these turtles were not adequate to deal with the productivity of the system.

420. In conclusion, the amphibians and reptiles of present-day Lake Conway represent a diverse but remnant fauna stressed primarily by the activities of man. Presumably many herpetofaunal species have benefitted from the food and shelter provided by recent increases in macrophyte primary productivity. However, the dependence of most species on an intact shoreline, and the rapid conversion of this habitat to beach-front property have countered any possible gains. The introduction of white amur as an aquatic plant control agent added yet another dimension to the complex processes regulating the herpetofaunal species of this lake system. Fortunately, the low stocking rate employed by WES (Addor and Theriot 1977) mitigated many of the potentially adverse effects of the fish. However, even under these conditions macrophyte removal by white amur, acting in concert with or perhaps synergistically with other disturbance phenomena, has caused significant ecological changes in the herpetofauna of Lake Conway.

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APPENDIX A

SUMMARY OF SAMPLING METHODS, POOL TOTALS, PERMANENT SITE TOTALS, FUNNEL TRAP CAPTURES, AND HERP-PATROL RESULTS (TOTAL SAMPLE AND BREEDING FROGS ONLY) ON LAKE CONWAY DURING THE THREE-YEAR STUDY

Table A1

The distribution by sampling method of all amphibians and reptiles observed or collected on Lake Conway during the three-year study. Summaries include the total number of individuals of a species taken each year by a sampling method, the percentage that the method (M%) contributed to the species total, and the percentage that the species (S%) contributed to the method total. Sampling methods recorded are: Alligator Census (AC), Drift Fence (DF), Electro-fishing (EF), Funnel Trap (FT), Herp-patrol (HP), Hyacinth Sieve (HS), Shoreline Census (SC), and Other Methods (OM).

	Year	AC	DF	EF	FT	HP	HS	SC	OM	Total	
AMPHIBIA CAUDATA											
Amphiuma means	(1)	0	2	1	245	2	11	1	0	262	
	(2)	0	0	0	77	1	0	3	0	81	
	(3)	0	0	0	28	2	8	0	0	38	
Total		0	2	1	350	5	19	4	0	381	(3.19%)
M%		--	0.52	0.26	91.86	1.31	4.99	1.05	--		
S%		--	2.99	2.08	44.81	0.05	28.36	1.64	--		
Amphiuma means (egg clutches)	(1)	0	0	0	0	0	0	0	0	0	
	(2)	0	0	0	0	0	0	2	0	2	
	(3)	0	0	0	0	0	0	0	0	0	
Total		0	0	0	0	0	0	2	0	2	(0.02%)
M%		--	--	--	--	--	--	100.00	--		
S%		--	--	--	--	--	--	0.82	--		

Table A1 (Continued)

	Year	AC	DF	EF	FT	HP	HS	SC	OM	Total
<u>Eurycea quadridigitata</u>	(1)	0	0	0	0	0	0	2	0	2
	(2)	0	0	0	0	0	0	0	0	0
	(3)	0	0	0	0	0	0	0	0	0
Total		0	0	0	0	0	0	2	0	2 (0.02%)
M%		--	--	--	--	--	--	100.00	--	
S%		--	--	--	--	--	--	0.82	--	
<u>Pseudobranchus striatus</u>	(1)	0	0	0	0	0	0	0	0	0
	(2)	0	0	0	1	0	0	0	0	1
	(3)	0	0	0	0	0	1	0	0	1
Total		0	0	0	1	0	1	0	0	2 (0.02%)
M%		--	--	--	50.00	--	50.00	--	--	
S%		--	--	--	0.13	--	1.49	--	--	
<u>Siren lacertina</u>	(1)	0	2	1	68	31	9	3	2	116
	(2)	0	0	2	36	17	0	1	3	59
	(3)	0	0	2	8	33	8	0	12	63
Total		0	2	5	112	81	17	4	17	238 (1.99%)
M%		--	0.84	2.10	47.06	34.03	7.14	1.68	7.14	
S%		--	2.99	10.42	14.34	0.78	25.37	1.64	6.44	

(Sheet 2 of 15)

Table A1 (Continued)

	Year	AC	DF	EF	FT	HP	HS	SC	OM	Total
ANURA										
Acris gryllus (adults)	(1)	0	0	0	0	825	0	6	0	831
	(2)	0	0	0	0	253	0	0	0	253
	(3)	0	0	0	0	279	0	0	0	279
Total		0	0	0	0	1357	0	6	0	1363(11.43%)
M%		--	--	--	--	99.56	--	0.44	--	
S%		--	--	--	--	13.11	--	2.46	--	
Acris gryllus (larvae)	(1)	0	0	0	1	0	0	0	0	1
	(2)	0	0	0	0	0	0	0	0	0
	(3)	0	0	0	0	0	0	0	0	0
Total		0	0	0	1	0	0	0	0	1 (0.01%)
M%		--	--	--	100.00	--	--	--	--	
S%		--	--	--	0.13	--	--	--	--	

(Sheet 3 of 15)

Table A1 (Continued)

	Year	AC	DF	EF	FT	HP	HS	SC	OM	Total
Bufo terrestris (adults)	(1)	0	0	0	0	299	0	0	0	299
	(2)	0	0	0	0	24	0	4	0	28
	(3)	0	0	0	0	60	0	20	0	80
Total		0	0	0	0	383	0	24	0	407 (3.41%)
M%		--	--	--	--	94.10	--	5.90	--	
S%		--	--	--	--	3.70	--	9.84	--	
Bufo terrestris (larvae)	(1)	0	0	0	0	300	0	1	0	301
	(2)	0	0	0	0	101	0	0	0	101
	(3)	0	0	0	0	0	0	0	0	0
Total		0	0	0	0	401	0	1	0	402 (3.37%)
M%		--	--	--	--	99.75	--	0.25	--	
S%		--	--	--	--	3.88	--	0.41	--	
Gastrophryne carolinensis (adults)	(1)	0	0	0	0	73	0	5	0	78
	(2)	0	0	0	1	49	0	0	0	50
	(3)	0	0	0	0	45	0	1	0	46
Total		0	0	0	1	167	0	6	0	174 (1.46%)
M%		--	--	--	0.57	95.98	--	3.45	--	
S%		--	--	--	0.13	1.61	--	2.46	--	

(Sheet 4 of 15)

Table A1 (Continued)

	Year	AC	DF	EF	FT	HP	HS	SC	OM	Total
Hyla cinerea (adults)	(1)	0	0	0	0	1303	3	10	0	1316
	(2)	0	0	0	1	703	0	0	0	704
	(3)	0	0	0	0	607	1	0	0	608
Total		0	0	0	1	2613	4	10	0	2628 (22.03%)
M%		--	--	--	0.04	99.43	0.15	0.38	--	
S%		--	--	--	0.13	25.25	5.97	4.10	--	
Hyla cinerea (larvae)	(1)	0	0	0	11	0	6	0	0	17
	(2)	0	0	0	0	0	0	0	0	0
	(3)	0	0	0	0	0	1	0	0	1
Total		0	0	0	11	0	7	0	0	18 (0.15%)
M%		--	--	--	61.11	--	38.89	--	--	
S%		--	--	--	1.41	--	10.45	--	--	
Hyla femoralis (adults)	(1)	0	0	0	0	4	0	0	0	4
	(2)	0	0	0	0	0	0	0	0	0
	(3)	0	0	0	0	0	0	0	0	0
Total		0	0	0	0	4	0	0	0	4 (0.03%)
M%		--	--	--	--	100.00	--	--	--	
S%		--	--	--	--	0.04	--	--	--	

(Sheet 5 of 15)

Table A1 (Continued)

	Year	AC	DF	EF	FT	HP	HS	SC	OM	Total
Hyla squirella (adults)	(1)	0	0	0	0	7	0	0	0	7
	(2)	0	0	0	0	10	0	0	0	10
	(3)	0	0	0	0	0	0	0	0	0
Total		0	0	0	0	17	0	0	0	17 (0.14%)
M%		--	--	--	--	100.00	--	--	--	
S%		--	--	--	--	0.16	--	--	--	
Rana grylio (adults)	(1)	0	0	0	6	51	0	2	0	59
	(2)	0	0	0	7	56	0	0	0	63
	(3)	0	0	0	5	104	3	0	0	112
Total		0	0	0	18	211	3	2	0	234 (1.96%)
M%		--	--	--	7.69	90.17	1.28	0.85	--	
S%		--	--	--	2.30	2.04	4.48	0.82	--	
Rana grylio (larvae)	(1)	0	31	0	11	0	1	0	0	43
	(2)	0	0	0	8	0	0	0	0	8
	(3)	0	0	0	6	0	2	0	0	8
Total		0	31	0	25	0	3	0	0	59 (0.49%)
M%		--	52.54	--	42.37	--	5.08	--	--	
S%		--	46.27	--	3.20	--	4.48	--	--	

(Sheet 6 of 15)

Table A1 (Continued)

	Year	AC	DF	EF	FT	HP	HS	SC	OM	Total
Rana utricularia (adults)	(1)	0	0	0	1	149	0	3	0	153
	(2)	0	0	0	4	171	0	0	0	175
	(3)	0	0	0	2	160	0	1	0	163
Total		0	0	0	7	480	0	4	0	491 (4.12%)
M%		--	--	--	1.43	97.76	--	0.81	--	
S%		--	--	--	0.90	4.64	--	1.64	--	
Rana utricularia (larvae)	(1)	0	23	0	10	0	3	0	0	36
	(2)	0	0	0	44	0	0	0	0	44
	(3)	0	0	0	1	0	0	0	0	1
Total		0	23	0	55	0	3	0	0	81 (0.68%)
M%		--	28.40	--	67.90	--	3.70	--	--	
S%		--	34.33	--	7.04	--	4.48	--	--	
Rana utricularia (egg clutches)	(1)	0	0	0	0	3	0	2	0	5
	(2)	0	0	0	0	0	0	0	0	0
	(3)	0	0	0	0	0	0	0	0	0
Total		0	0	0	0	3	0	2	0	5 (0.04%)
M%		--	--	--	--	60.00	--	40.00	--	
S%		--	--	--	--	0.03	--	0.82	--	

(Sheet 7 of 15)

Table A1 (Continued)

	Year	AC	DF	EF	FT	HP	HS	SC	OM	Total
REPTILIA										
CROCODILIA										
Alligator mississippiensis	(1)	46	1	0	0	91	0	15	0	153
	(2)	42	0	0	0	41	0	1	0	84
	(3)	22	0	0	0	22	0	0	2	46
Total		110	1	0	0	154	0	16	2	283 (2.37%)
M%		38.87	0.35	--	--	54.42	--	5.65	0.71	
S%		100.00	1.49	--	--	1.49	--	6.56	0.76	
Alligator mississippiensis (egg clutches)	(1)	0	0	0	0	1	0	1	0	2
	(2)	0	0	0	0	0	0	0	0	0
	(3)	0	0	0	0	0	0	0	0	0
Total		0	0	0	0	1	0	1	0	2 (0.02%)
M%		--	--	--	--	50.00	--	50.00	--	
S%		--	--	--	--	0.01	--	0.41	--	

(Sheet 8 of 15)

Table A1 (Continued)

	Year	AC	DF	EF	FT	HP	HS	SC	OM	Total
TESTUDINATA										
Chelydra serpentina	(1)	0	0	0	1	2	0	1	0	4
	(2)	0	0	0	8	5	0	0	0	13
	(3)	0	0	0	3	1	0	0	0	4
Total		0	0	0	12	8	0	1	0	21 (0.18%)
M%		--	--	--	57.14	38.10	--	4.76	--	
S%		--	--	--	1.54	0.08	--	0.41	--	
Deirochelys reticularia	(1)	0	0	0	0	1	0	0	0	1
	(2)	0	0	0	0	2	0	0	0	2
	(3)	0	0	0	0	0	0	0	0	0
Total		0	0	0	0	3	0	0	0	3 (0.02%)
M%		--	--	--	--	100.00	--	--	--	
S%		--	--	--	--	0.03	--	--	--	

(Sheet 9 of 15)

Table A1 (Continued)

	Year	AC	DF	EF	FT	HP	HS	SC	OM	Total
Kinosternon baurii	(1)	0	3	0	2	2	0	1	0	8
	(2)	0	0	0	1	0	0	1	0	2
	(3)	0	0	0	1	1	0	1	1	4
Total		0	3	0	4	3	0	3	1	14 (0.12%)
M%		--	21.43	--	28.57	21.43	--	21.43	7.14	
S%		--	4.48	--	0.51	0.03	--	1.23	0.38	
Kinosternon subrubrum	(1)	0	0	2	27	26	0	0	0	55
	(2)	0	0	0	2	12	0	0	0	14
	(3)	0	0	0	1	10	0	0	10	21
Total		0	0	2	30	48	0	0	10	90 (0.75%)
M%		--	--	2.22	33.33	53.33	--	--	11.11	
S%		--	--	4.17	3.84	0.46	--	--	3.79	
Pseudemys floridana	(1)	0	0	1	2	339	0	3	0	345
	(2)	0	0	2	0	181	0	2	2	187
	(3)	0	0	1	0	299	0	15	54	369
Total		0	0	4	2	819	0	20	56	901 (7.55%)
M%		--	--	0.44	0.22	90.90	--	2.22	6.22	
S%		--	--	8.33	0.26	7.92	--	8.20	21.21	

(Sheet 10 of 15)

Table A1 (Continued)

	Year	AC	DF	EF	FT	HP	HS	SC	OM	Total
Pseudemys floridana (eggs)	(1)	0	0	0	0	0	0	0	0	0
	(2)	0	0	0	0	0	0	0	0	0
	(3)	0	0	0	0	1	0	0	0	1
Total		0	0	0	0	1	0	0	0	1 (0.01%)
M%		--	--	--	--	100.00	--	--	--	
S%		--	--	--	--	0.01	--	--	--	
Pseudemys nelsoni	(1)	0	0	2	1	97	0	2	0	102
	(2)	0	0	1	0	57	0	6	0	64
	(3)	0	0	0	0	34	0	9	17	60
Total		0	0	3	1	188	0	17	17	226 (1.89%)
M%		--	--	1.33	0.44	83.19	--	7.52	7.52	
S%		--	--	6.25	0.13	1.82	--	6.97	6.44	
Pseudemys scripta	(1)	0	0	0	0	0	0	0	0	0
	(2)	0	0	0	1	0	0	1	0	2
	(3)	0	0	0	0	1	0	0	0	1
Total		0	0	0	1	1	0	1	0	3 (0.02%)
M%		--	--	--	33.33	33.33	--	33.33	--	
S%		--	--	--	0.13	0.01	--	0.41	--	

(Sheet 11 of 15)

Table A1 (Continued)

	Year	AC	DF	EF	FT	HP	HS	SC	OM	Total
Sternotherus odoratus	(1)	0	0	20	27	1290	1	4	0	1342
	(2)	0	0	3	15	1222	0	16	1	1257
	(3)	0	0	3	14	732	9	7	152	917
Total		0	0	26	56	3244	10	27	153	3516 (29.48%)
M%		--	--	0.74	1.59	92.26	0.28	0.77	4.35	
S%		--	--	54.17	7.17	31.35	14.93	11.07	57.95	
Sternotherus odoratus (eggs)	(1)	0	0	0	0	5	0	0	0	5
	(2)	0	0	0	0	0	0	2	0	2
	(3)	0	0	0	0	0	0	0	0	0
Total		0	0	0	0	5	0	2	0	7 (0.06%)
M%		--	--	--	--	71.43	--	28.57	--	
S%		--	--	--	--	0.05	--	0.82	--	
Trionyx ferox	(1)	0	0	0	2	21	0	1	0	24
	(2)	0	0	0	0	5	0	2	0	7
	(3)	0	0	0	0	6	0	2	4	12
Total		0	0	0	2	32	0	5	4	43 (0.36%)
M%		--	--	--	4.65	74.42	--	11.63	9.30	
S%		--	--	--	0.26	0.31	--	2.05	1.52	

(Sheet 12 of 15)

Table A1 (Continued)

	Year	AC	DF	EF	FT	HP	HS	SC	OM	Total
Trionyx ferox										
(eggs)	(1)	0	0	0	0	0	0	0	0	0
	(2)	0	0	0	0	0	0	3	0	3
	(3)	0	0	0	0	0	0	4	0	4
Total		0	0	0	0	0	0	7	0	7 (0.06%)
M%		--	--	--	--	--	--	100.00	--	
S%		--	--	--	--	--	--	2.87	--	
REPTILIA SQUAMATA										
Coluber constrictor	(1)	0	1	0	0	0	0	1	0	2
	(2)	0	0	0	0	0	0	0	0	0
	(3)	0	0	0	0	0	0	0	0	0
Total		0	1	0	0	0	0	1	0	2 (0.02%)
M%		--	50.00	--	--	--	--	50.00	--	
S%		--	1.49	--	--	--	--	0.01	--	
Farancia abacura	(1)	0	0	0	1	1	0	2	0	4
	(2)	0	0	0	1	0	0	1	0	2
	(3)	0	0	0	0	0	0	0	0	0
Total		0	0	0	2	1	0	3	0	6 (0.05%)
M%		--	--	--	33.33	16.67	--	50.00	--	
S%		--	--	--	0.26	0.01	--	1.23	--	

(Sheet 13 of 15)

Table A1 (Continued)

	Year	AC	DF	EF	FT	HP	HS	SC	OM	Total
Nerodia cyclopion	(1)	0	0	5	58	75	0	44	1	183
	(2)	0	0	0	11	9	0	3	0	23
	(3)	0	0	2	9	5	0	8	3	27
Total		0	0	7	78	89	0	55	4	233 (1.95%)
M%		--	--	3.00	33.48	38.20	--	23.61	1.72	
S%		--	--	14.58	9.99	0.86	--	22.54	1.52	
Nerodia fasciata	(1)	0	1	0	1	18	0	5	0	25
	(2)	0	0	0	4	5	0	3	0	12
	(3)	0	0	0	2	4	0	3	0	9
Total		0	1	0	7	27	0	11	0	46 (0.38%)
M%		--	2.17	--	15.22	58.70	--	23.91	--	
S%		--	1.49	--	0.90	0.26	--	4.51	--	
Regina alleni	(1)	0	0	0	0	0	0	2	0	2
	(2)	0	0	0	3	0	0	1	0	4
	(3)	0	0	0	1	0	0	0	0	1
Total		0	0	0	4	0	0	3	0	7 (0.06%)
M%		--	--	--	57.14	--	--	42.86	--	
S%		--	--	--	0.51	--	--	1.23	--	

(Sheet 14 of 15)

Table A1 (Concluded)

	Year	AC	DF	EF	FT	HP	HS	SC	CM	Total
Thamnophis sauritus	(1)	0	3	0	0	0	0	3	0	6
	(2)	0	0	0	0	0	0	0	0	0
	(3)	0	0	0	0	0	0	0	0	0
Total		0	3	0	0	0	0	3	0	6 (0.05%)
M%		--	50.00	--	--	--	--	50.00	--	
S%		--	4.48	--	--	--	--	1.23	--	
Thamnophis sirtalis	(1)	0	0	0	0	0	0	2	0	2
	(2)	0	0	0	0	0	0	0	0	0
	(3)	0	0	0	0	0	0	0	0	0
Total		0	0	0	0	0	0	2	0	2 (0.02%)
M%		--	--	--	--	--	--	100.00	--	
S%		--	--	--	--	--	--	0.82	--	
Number of Individuals		110	67	48	781	10346	67	245	264	11928
Number of Species		1	7	7	20	23	9	24	9	
	M%	0.9	0.6	0.4	6.5	86.7	0.6	2.0	2.2	

(Sheet 15 of 15)

Table A2

The distribution and relative abundance by year of amphibians and reptiles observed or captured on Lake Conway during the three-year study. Pool summaries include the number of species by major taxonomic unit (parentheses), the total number of individuals of species recorded within a pool (numerical values), and the species' relative abundance between pools (percentages).

		Year	SOUTH POOL	MIDDLE POOL	EAST POOL	WEST POOL	LAKE GATLIN	Total
AMPHIBIA			(8)	(9)	(9)	(8)	(8)	(12)
CAUDATA			(2)	(2)	(4)	(2)	(2)	(4)
Amphiuma means (adults)		1	21	14	158	62	7	262
		2	3	3	45	23	7	81
		3	1	0	32	3	2	38
	Total		25	17	235	88	16	381
	%		0.21	0.14	1.97	0.74	0.13	3.19
Amphiuma means (egg clutches)		1	0	0	0	0	0	0
		2	2	0	0	0	0	2
		3	0	0	0	0	0	0
	Total		2	0	0	0	0	2
	%		0.02	--	--	--	--	0.02
Eurycea quadridigitata		1	0	0	2	0	0	2
		2	0	0	0	0	0	0
		3	0	0	0	0	0	0
	Total		0	0	2	0	0	2
	%		--	--	0.02	--	--	0.02

(Sheet 1 of 10)

Table A2 (Continued)

	Year	SOUTH POOL	MIDDLE POOL	EAST POOL	WEST POOL	LAKE GATLIN	Total
Pseudobranchus striatus	1	0	0	0	0	0	0
	2	0	0	1	0	0	1
	3	0	0	1	0	0	1
Total		0	0	2	0	0	2
%		--	--	0.02	--	--	0.02
Siren lacertina	1	2	20	62	26	6	116
	2	8	6	32	10	3	59
	3	9	5	37	8	4	63
Total		19	31	131	44	13	238
%		0.16	0.26	1.10	0.37	0.11	2.00
ANURA		(6)	(7)	(5)	(6)	(6)	(8)
Acris gryllus (adults)	1	508	148	135	26	14	831
	2	133	38	68	2	12	253
	3	132	30	103	0	14	279
Total		773	216	306	28	40	1363
%		6.48	1.81	2.57	0.23	0.34	11.43
Acris gryllus (larvae)	1	0	1	0	0	0	1
	2	0	0	0	0	0	0
	3	0	0	0	0	0	0
Total		0	1	0	0	0	1
%		--	0.01	--	--	--	0.01

(Sheet 2 of 10)

Table A2 (Continued)

	Year	SOUTH POOL	MIDDLE POOL	EAST POOL	WEST POOL	LAKE GATLIN	Total
Bufo terrestris (adults)	1	13	33	204	24	25	299
	2	3	4	0	4	17	28
	3	15	19	1	12	33	80
Total		31	56	205	40	75	407
%		0.26	0.47	1.72	0.34	0.63	3.41
Bufo terrestris (larvae)	1	0	0	0	0	301	301
	2	0	0	0	0	101	101
	3	0	0	0	0	0	0
Total		0	0	0	0	402	402
%		--	--	--	--	3.37	3.37
Gastrophryne carolinensis (adults)	1	5	12	0	57	4	78
	2	3	3	0	40	4	50
	3	1	2	0	42	1	46
Total		9	17	0	139	9	174
%		0.08	0.14	--	1.17	0.08	1.46
Hyla cinerea (adults)	1	47	209	448	553	59	1316
	2	34	55	108	370	137	704
	3	11	82	164	141	210	608
Total		92	346	720	1064	406	2628
%		0.77	2.90	6.04	8.92	3.40	22.03

(Sheet 3 of 10)

Table A2 (Continued)

		Year	SOUTH POOL	MIDDLE POOL	EAST POOL	WEST POOL	LAKE GATLIN	Total
Hyla cinerea (larvae)		1	1	0	14	2	0	17
		2	0	0	0	0	0	0
		3	0	0	1	0	0	1
	Total		1	0	15	2	0	18
	%		0.01	--	0.13	0.02	--	0.15
Hyla femoralis (adults)		1	0	4	0	0	0	4
		2	0	0	0	0	0	0
		3	0	0	0	0	0	0
	Total		0	4	0	0	0	4
	%		--	0.03	--	--	--	0.03
Hyla squirella (adults)		1	7	0	0	0	0	7
		2	10	0	0	0	0	10
		3	0	0	0	0	0	0
	Total		17	0	0	0	0	17
	%		0.14	--	--	--	--	0.14
Rana grylio (adults)		1	0	38	18	0	3	59
		2	0	10	16	17	20	63
		3	0	38	24	0	50	112
	Total		0	86	58	17	73	234
	%		--	0.72	0.49	0.14	0.61	1.96

(Sheet 4 of 10)

Table A2 (Continued)

		Year	SOUTH POOL	MIDDLE POOL	EAST POOL	WEST POOL	LAKE GATLIN	Total
Rana grylio (larvae)		1	0	37	6	0	0	43
		2	0	4	1	0	3	8
		3	0	0	4	0	4	8
	Total		0	41	11	0	7	59
	%		--	0.34	0.09	--	0.06	0.49
Rana utricularia (adults)		1	30	15	28	50	30	153
		2	44	28	14	34	55	175
		3	16	81	7	21	38	163
	Total		90	124	49	105	123	491
	%		0.75	1.04	0.41	0.88	1.03	4.12
Rana utricularia (egg clutches)		1	1	0	0	4	0	5
		2	0	0	0	0	0	0
		3	0	0	0	0	0	0
	Total		1	0	0	4	0	5
	%		0.01	--	--	0.03	--	0.04
Rana utricularia (larvae)		1	1	28	5	2	0	36
		2	4	24	12	2	2	44
		3	0	0	0	0	1	1
	Total		5	52	17	4	3	81
	%		0.04	0.44	0.14	0.03	0.03	0.68

(Sheet 5 of 10)

Table A2 (Continued)

	Year	SOUTH POOL	MIDDLE POOL	EAST POOL	WEST POOL	LAKE GATLIN	Total
REPTILIA		(15)	(11)	(11)	(9)	(12)	(17)
CROCODILIA		(1)	(1)	(1)	(1)	(1)	(1)
Alligator mississippiensis	1	1	72	76	2	2	153
	2	4	18	58	2	2	84
	3	2	14	25	0	5	46
Total		7	104	159	4	9	283
%		0.06	0.87	1.33	0.03	0.08	2.37
Alligator mississippiensis (egg clutches)	1	0	1	1	0	0	2
	2	0	0	0	0	0	0
	3	0	0	0	0	0	0
Total		0	1	1	0	0	2
%		--	0.01	0.01	--	--	0.02
TESTUDINATA		(8)	(6)	(6)	(6)	(8)	(9)
Chelydra serpentina	1	0	0	1	1	2	4
	2	1	0	2	5	5	13
	3	0	0	2	2	0	4
Total		1	0	5	8	7	21
%		0.01	--	0.04	0.07	0.06	0.18
Deirochelys reticularia	1	0	0	0	0	1	1
	2	0	0	0	0	2	2
	3	0	0	0	0	0	0
Total		0	0	0	0	3	3
%		--	--	--	--	0.03	0.03

(Sheet 6 of 10)

Table A2 (Continued)

	Year	SOUTH POOL	MIDDLE POOL	EAST POOL	WEST POOL	LAKE GATLIN	Total
Kinosternon baurii	1	6	1	0	0	1	8
	2	1	0	0	0	1	2
	3	3	0	0	0	1	4
Total		10	1	0	0	3	14
%		0.08	0.01	--	--	0.03	0.12
Kinosternon subrubrum	1	38	7	0	1	9	55
	2	10	0	0	2	2	14
	3	9	1	3	8	0	21
Total		57	8	3	11	11	90
%		0.48	0.07	0.03	0.09	0.09	0.75
Pseudemys floridana	1	153	79	53	4	56	345
	2	82	33	34	9	29	187
	3	235	24	74	12	24	369
Total		470	136	161	25	109	901
%		3.94	1.14	1.35	0.21	0.91	7.55
Pseudemys floridana (eggs)	1	0	0	0	0	0	0
	2	0	0	0	0	0	0
	3	1	0	0	0	0	1
Total		1	0	0	0	0	1
%		0.01	--	--	--	--	0.01
Pseudemys nelsoni	1	20	30	21	3	28	102
	2	13	13	6	5	27	64
	3	12	10	27	2	9	60
Total		45	53	54	10	64	226
%		0.38	0.44	0.45	0.08	0.54	1.89

(Sheet 7 of 10)

Table A2 (Continued)

		Year	SOUTH POOL	MIDDLE POOL	EAST POOL	WEST POOL	LAKE GATLIN	Total
Pseudemys scripta		1	0	0	0	0	0	0
		2	2	0	0	0	0	2
		3	1	0	0	0	0	1
	Total		3	0	0	0	0	3
	%		0.03	--	--	--	--	0.03
Sternotherus odoratus		1	421	421	86	57	357	1342
		2	648	200	71	280	58	1257
		3	488	109	109	194	17	917
	Total		1557	730	266	531	432	3516
	%		13.05	6.12	2.23	4.45	3.62	29.48
Sternotherus odoratus (eggs)		1	0	2	2	0	1	5
		2	2	0	0	0	0	2
		3	0	0	0	0	0	0
	Total		2	2	2	0	1	7
	%		0.02	0.02	0.02	--	0.01	0.06
Trionyx ferox		1	8	4	4	0	8	24
		2	4	1	1	1	0	7
		3	3	4	3	1	1	12
	Total		15	9	8	2	9	43
	%		0.13	0.08	0.07	0.02	0.08	0.36

(Sheet 8 of 10)

Table A2 (Continued)

		Year	SOUTH POOL	MIDDLE POOL	EAST POOL	WEST POOL	LAKE GATLIN	Total
Trionyx ferox (eggs)		1	0	0	0	0	0	0
		2	0	3	0	0	0	3
		3	4	0	0	0	0	4
	Total		4	3	0	0	0	7
	%		0.03	0.03	--	--	--	0.06
SQUAMATA			(6)	(4)	(4)	(2)	(3)	(7)
Coluber constrictor		1	2	0	0	0	0	2
		2	0	0	0	0	0	0
		3	0	0	0	0	0	0
	Total		2	0	0	0	0	2
	%		0.02	--	--	--	--	0.02
Farancia abacura		1	3	0	1	0	0	4
		2	1	0	0	0	1	2
		3	0	0	0	0	0	0
	Total		4	0	1	0	1	6
	%		0.03	--	0.01	--	0.01	0.05
Nerodia cyclopion		1	101	23	26	13	20	183
		2	4	1	10	4	4	23
		3	3	1	22	0	1	27
	Total		108	25	58	17	25	233
	%		0.91	0.21	0.49	0.14	0.21	1.95

(Sheet 9 of 10)

Table A2 (Concluded)

		Year	SOUTH POOL	MIDDLE POOL	EAST POOL	WEST POOL	LAKE GATLIN	Total
Nerodia fasciata		1	3	8	0	0	14	25
		2	3	1	0	3	5	12
		3	2	3	1	0	3	9
	Total		8	12	1	3	22	46
	%		0.07	0.10	0.01	0.03	0.18	0.39
Regina alleni		1	2	0	0	0	0	2
		2	1	3	0	0	0	4
		3	0	1	0	0	0	1
	Total		3	4	0	0	0	7
	%		0.03	0.03	--	--	--	0.06
Thamnophis sauritus		1	0	5	1	0	0	6
		2	0	0	0	0	0	0
		3	0	0	0	0	0	0
	Total		0	5	1	0	0	6
	%		--	0.04	0.01	--	--	0.05
Thamnophis sirtalis		1	2	0	0	0	0	2
		2	0	0	0	0	0	0
		3	0	0	0	0	0	0
	Total		2	0	0	0	0	2
	%		0.02	--	--	--	--	0.02
	Pool Total		3364	2084	2471	2146	1863	11928
	%		28.20	17.47	20.72	17.99	15.62	100.00

(Sheet 10 of 10)

Table A3

The distribution of reptiles and amphibians recorded from the permanent sites in each pool during the three-year study. Summary values include the number of species by major taxonomic unit (parentheses), the total number of individuals of a species seen or captured by all sampling methods for each year and for total years, and their percent contribution to the total sample.

		Year	SOUTH POOL	MIDDLE POOL	EAST POOL	WEST POOL	GATLIN CANAL	Total
AMPHIBIA			(8)	(8)	(8)	(8)	(8)	
CAUDATA			(2)	(2)	(4)	(2)	(2)	
Amphiuma means (adults)		1	21	14	143	62	7	247
		2	3	3	38	23	7	74
		3	0	0	24	3	2	29
	Total		24	17	205	88	16	350
	%		0.31	0.22	2.64	1.13	0.21	4.51
Amphiuma means (egg clutches)		1	0	0	0	0	0	0
		2	2	0	0	0	0	2
		3	0	0	0	0	0	0
	Total		2	0	0	0	0	2
	%		0.03	--	--	--	--	0.03

(Sheet 1 of 10)

Table A3 (Continued)

	Year	SOUTH POOL	MIDDLE POOL	EAST POOL	WEST POOL	GATLIN CANAL	Total
Eurycea quadridigitata	1	0	0	2	0	0	2
	2	0	0	0	0	0	0
	3	0	0	0	0	0	0
Total		0	0	2	0	0	2
%		--	--	0.03	--	--	0.03
Pseudobranchus striatus	1	0	0	0	0	0	0
	2	0	0	0	0	0	0
	3	0	0	1	0	0	1
Total		0	0	1	0	0	1
%		--	--	0.01	--	--	0.01
Siren lacertina	1	1	15	37	23	6	82
	2	6	3	15	7	3	34
	3	3	2	22	0	4	31
Total		10	20	74	30	13	147
%		0.13	0.26	0.95	0.39	0.17	1.90
ANURA		(6)	(6)	(4)	(6)	(6)	
Acris gryllus (adults)	1	503	98	78	11	14	704
	2	133	38	68	2	12	253
	3	132	30	103	0	14	279
Total		768	166	249	13	40	1236
%		9.90	2.14	3.21	0.17	0.52	15.94

(Sheet 2 of 10)

Table A3 (Continued)

		Year	SOUTH POOL	MIDDLE POOL	EAST POOL	WEST POOL	GATLIN CANAL	Total
Acris gryllus (larvae)		1	0	1	0	0	0	1
		2	0	0	0	0	0	0
		3	0	0	0	0	0	0
	Total		0	1	0	0	0	1
	%		--	0.01	--	--	--	0.01
Bufo terrestris (adults)		1	8	5	0	0	25	38
		2	1	0	0	0	17	18
		3	2	0	0	12	33	47
	Total		11	5	0	12	75	103
	%		0.14	0.06	--	0.15	0.97	1.33
Bufo terrestris (larvae)		1	0	0	0	0	1	1
		2	0	0	0	0	2	2
		3	0	0	0	0	0	0
	Total		0	0	0	0	3	3
	%		--	--	--	--	0.04	0.04
Gastrophryne carolinensis (adults		1	5	8	0	57	4	74
		2	3	3	0	40	4	50
		3	1	1	0	42	1	45
	Total		9	12	0	139	9	169
	%		0.12	0.15	--	1.79	0.12	2.18

(Sheet 3 of 10)

Table A3 (Continued)

		Year	SOUTH POOL	MIDDLE POOL	EAST POOL	WEST POOL	GATLIN CANAL	Total
Hyla cinerea (adults)		1	37	134	383	538	59	1151
		2	34	55	108	370	137	704
		3	11	81	164	139	210	605
	Total		82	270	655	1047	406	2460
	%		1.06	3.48	8.45	13.50	5.24	31.73
Hyla cinerea (larvae)		1	1	0	14	2	0	17
		2	0	0	0	0	0	0
		3	0	0	1	0	0	1
	Total		1	0	15	2	0	18
	%		0.01	--	0.19	0.03	--	0.23
Hyla squirella (adults)		1	7	0	0	0	0	7
		2	10	0	0	0	0	10
		3	0	0	0	0	0	0
	Total		17	0	0	0	0	17
	%		0.22	--	--	--	--	0.22
Rana grylio (adults)		1	0	28	16	0	3	47
		2	0	10	16	17	20	63
		3	0	38	24	0	50	112
	Total		0	76	56	17	73	222
	%		--	0.98	0.72	0.22	0.94	2.86

(Sheet 4 of 10)

Table A3 (Continued)

		Year	SOUTH POOL	MIDDLE POOL	EAST POOL	WEST POOL	GATLIN CANAL	Total
Rana grylio (larvae)		1	0	37	6	0	0	43
		2	0	4	1	0	3	8
		3	0	0	3	0	4	7
	Total		0	41	10	0	7	58
	%		--	0.53	0.13	--	0.09	0.75
Rana utricularia (adults)		1	30	14	27	50	30	151
		2	44	28	14	34	55	175
		3	16	81	6	21	38	162
	Total		90	123	47	105	123	488
	%		1.16	1.59	0.61	1.35	1.59	6.29
Rana utricularia (larvae)		1	1	28	5	2	0	36
		2	4	24	12	2	2	44
		3	0	0	0	0	1	1
	Total		5	52	17	4	3	81
	%		0.06	0.67	0.22	0.05	0.04	1.04
Rana utricularia (egg clutches)		1	1	0	0	4	0	5
		2	0	0	0	0	0	0
		3	0	0	0	0	0	0
	Total		1	0	0	4	0	5
	%		0.01	--	--	0.05	--	0.06

(Sheet 5 of 10)

Table A3 (Continued)

	Year	SOUTH POOL	MIDDLE POOL	EAST POOL	WEST POOL	GATLIN CANAL	Total
REPTILIA		(15)	(11)	(9)	(8)	(12)	
CROCODILIA		(1)	(1)	(1)	(1)	(1)	
Alligator mississippiensis	1	0	21	1	0	0	22
	2	0	1	3	0	2	6
	3	0	1	1	0	2	4
Total		0	23	5	0	4	32
%		--	0.30	0.06	--	0.05	0.41
Alligator mississippiensis (egg clutches)	1	0	1	0	0	0	1
	2	0	0	0	0	0	0
	3	0	0	0	0	0	0
Total		0	1	0	0	0	1
%		--	0.01	--	--	--	0.01
TESTUDINATA		(8)	(6)	(5)	(5)	(8)	
Chelydra serpentina	1	0	0	1	1	2	4
	2	1	0	2	4	5	12
	3	0	0	2	2	0	4
Total		1	0	5	7	7	20
%		0.01	--	0.06	0.09	0.09	0.26
Deirochelys reticularia	1	0	0	0	0	1	1
	2	0	0	0	0	2	2
	3	0	0	0	0	0	0
Total		0	0	0	0	3	3
%		--	--	--	--	0.04	0.04

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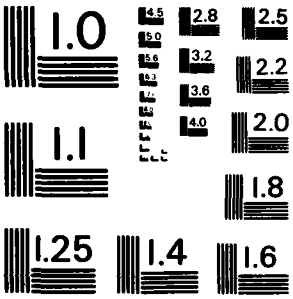

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Table A3 (Continued)

		Year	SOUTH POOL	MIDDLE POOL	EAST POOL	WEST POOL	GATLIN CANAL	Total
Kinosternon baurii		1	6	1	0	0	1	8
		2	1	0	0	0	1	2
		3	2	0	0	0	1	3
	Total		9	1	0	0	3	13
	%		0.12	0.01	--	--	0.04	0.17
Kinosternon subrubrum		1	38	2	0	1	7	48
		2	4	0	0	0	2	6
		3	3	0	0	0	0	3
	Total		45	2	0	1	9	57
	%		0.58	0.03	--	0.01	0.12	0.74
Pseudemys floridana		1	93	31	15	3	52	194
		2	9	0	9	3	29	50
		3	5	5	43	2	22	77
	Total		107	36	67	8	103	321
	%		1.38	0.46	0.86	0.10	1.33	4.14
Pseudemys nelsoni		1	12	8	3	2	27	52
		2	1	2	1	2	27	33
		3	3	0	6	1	9	19
	Total		16	10	10	5	63	104
	%		0.21	0.13	0.13	0.06	0.81	1.34
Pseudemys scripta		1	0	0	0	0	0	0
		2	2	0	0	0	0	2
		3	0	0	0	0	0	0
	Total		2	0	0	0	0	2
	%		0.03	--	--	--	--	0.03

(Sheet 7 of 10)

Table A3 (Continued)

		Year	SOUTH POOL	MIDDLE POOL	EAST POOL	WEST POOL	GATLIN CANAL	Total
Sternotherus odoratus		1	339	291	44	53	306	1033
		2	113	69	9	45	49	285
		3	113	65	13	21	17	229
	Total		565	425	66	119	372	1547
	%		7.29	5.48	0.85	1.53	4.80	19.95
Sternotherus odoratus (eggs)		1	0	0	2	0	1	3
		2	2	0	0	0	0	2
		3	0	0	0	0	0	0
	Total		2	0	2	0	1	5
	%		0.03	--	0.03	--	0.01	0.06
Trionyx ferox		1	8	1	2	0	6	17
		2	1	0	1	0	0	2
		3	0	0	1	0	1	2
	Total		9	1	4	0	7	21
	%		0.12	0.01	0.05	--	0.09	0.27
Trionyx ferox (eggs)		1	0	0	0	0	0	0
		2	0	3	0	0	0	3
		3	4	0	0	0	0	4
	Total		4	3	0	0	0	7
	%		0.05	0.04	--	--	--	0.09

(Sheet 8 of 10)

Table A3 (Continued)

		Year	SOUTH POOL	MIDDLE POOL	EAST POOL	WEST POOL	GATLIN CANAL	Total
SQUAMATA			(6)	(4)	(3)	(2)	(3)	
Coluber constrictor		1	2	0	0	0	0	2
		2	0	0	0	0	0	0
		3	0	0	0	0	0	0
	Total		2	0	0	0	0	2
	%		0.03	--	--	--	--	0.03
Farancia abacura		1	3	0	0	0	0	3
		2	1	0	0	0	1	2
		3	0	0	0	0	0	0
	Total		4	0	0	0	1	5
	%		0.05	--	--	--	0.01	0.06
Nerodia fasciata		1	3	2	0	0	14	19
		2	2	1	0	3	5	11
		3	2	1	1	0	3	7
	Total		7	4	1	3	22	37
	%		0.09	0.05	0.01	0.04	0.28	0.48
Nerodia cyclopion		1	98	10	20	13	19	160
		2	3	1	7	4	4	19
		3	2	0	17	0	1	20
	Total		103	11	44	17	24	199
	%		1.33	0.14	0.57	0.22	0.31	2.57

(Sheet 9 of 10)

Table A3 (Concluded)

	Year	SOUTH POOL	MIDDLE POOL	EAST POOL	WEST POOL	GATLIN CANAL	Total
Regina alleni	1	2	0	0	0	0	2
	2	1	3	0	0	0	4
	3	0	1	0	0	0	1
Total		3	4	0	0	0	7
%		0.04	0.05	--	--	--	0.09
Thamnophis sauritus	1	0	5	1	0	0	6
	2	0	0	0	0	0	0
	3	0	0	0	0	0	0
Total		0	5	1	0	0	6
%		--	0.06	0.01	--	--	0.08
Thamnophis sirtalis	1	2	0	0	0	0	2
	2	0	0	0	0	0	0
	3	0	0	0	0	0	0
Total		2	0	0	0	0	2
%		0.03	--	--	--	--	0.03
Pool Total		1901	1309	1536	1621	1387	7754
%		24.52	16.88	19.81	20.91	17.89	100.0

(Sheet 10 of 10)

Table A4

Comparisons of the distributions and mean relative densities of amphibians and reptiles at permanent shoreline sites as determined by funnel traps. Site summaries include total funnel trap days and mean relative density (mean number/100 trap days) for each species for each year. Chi-square values (X^2) are provided only if significant between-site differences were detected (* = P<.05, ** = P<.01); site means with the same letter indicate no significant differences between sites (P>.025). See text for details.

	Year	SOUTH POOL	MIDDLE POOL	EAST POOL	WEST POOL	GATLIN CANAL	Total	X^2
Funnel Traps (total days)	1	928	422	434	614	420	2818	
	2	1071	457	456	837	457	3278	
	3	1214	480	1120	804	440	4058	
Total		3213	1359	2010	2255	1317	10154	
AMPHIBIA								
CAUDATA								
Amphiuma means	1	2.26_A	2.83_A	30.41	9.45	1.67_A	8.16	371.1 **
	2	0.09	0.66_A	8.33	2.63_B	1.31_{AB}	2.14	112.4 **
	3	0.00_A	0.00_A	1.43_B	0.37_A	0.45_{AB}	0.52	27.23**
Total		0.68_A	1.10_A	9.25	3.68	1.14_A	3.16	361.99**
Siren lacertina	1	0.00	2.83_A	6.91	1.63_{AB}	0.71_B	1.95	79.74**
	2	0.28_A	0.66_{AB}	2.19_B	0.84_{AB}	0.66_{AB}	0.79	15.17**
	3	0.00	0.21	0.18	0.00	0.23	0.10	
Total		0.09	1.18_{AB}	2.09_A	0.75_B	0.53_B	0.84	65.78**

(Sheet 1 of 6)

Table A4 (Continued)

	Year	SOUTH POOL	MIDDLE POOL	EAST POOL	WEST POOL	GATLIN CANAL	Total	X^2
ANURA								
Acris gryllus (larvae)	1	0.00	0.24	0.00	0.00	0.00	0.04	
	2	0.00	0.00	0.00	0.00	0.00	0.00	
	3	0.00	0.00	0.00	0.00	0.00	0.00	
Total		0.00	0.07	0.00	0.00	0.00	0.01	
Gastrophryne carolinensis (adults)	1	0.00	0.00	0.00	0.00	0.00	0.00	
	2	0.00	0.00	0.00	0.12	0.00	0.03	
	3	0.00	0.00	0.00	0.00	0.00	0.00	
Total		0.00	0.00	0.00	0.04	0.00	0.01	
Hyla cinerea (adults)	1	0.00	0.00	0.00	0.00	0.00	0.00	
	2	0.00	0.00	0.00	0.12	0.00	0.03	
	3	0.00	0.00	0.00	0.00	0.00	0.00	
Total		0.00	0.00	0.00	0.04	0.00	0.01	
Hyla cinerea (larvae)	1	0.11_A	0.00_A	2.07	0.16_A	0.00_A	0.39	37.69**
	2	0.00^A	0.00^A	0.00	0.00^A	0.00^A	0.00	
	3	0.00	0.00	0.00	0.00	0.00	0.00	
Total		0.03_A	0.00_A	0.45	0.04_A	0.00_A	0.11	28.67**

(Sheet 2 of 6)

Table A4 (Continued)

		Year	SOUTH POOL	MIDDLE POOL	EAST POOL	WEST POOL	GATLIN CANAL	Total	X^2
Rana grylio (adults)		1	0.00_A	0.47_{AB}	0.92_B	0.00_A	0.00_{AB}	0.21	15.79**
		2	0.00_A	0.44_{AB}	0.44_{AB}	0.00_A	0.66_B	0.21	10.45*
		3	0.00_A	0.21_{AB}	0.09_{AB}	0.00_A	0.68_B	0.12	14.03**
	Total		0.00_A	0.37_B	0.35_B	0.00_A	0.46_B	0.18	22.66**
Rana grylio (larvae)		1	0.00_A	1.18_B	1.38_B	0.00_A	0.00_A	0.39	25.48**
		2	0.00_A	0.88_B	0.22_{AB}	0.00_A	0.66_B	0.24	15.35**
		3	0.00_A	0.00_A	0.18_{AB}	0.00_{AB}	0.91_B	0.15	21.04**
	Total		0.00_A	0.66_B	0.45_B	0.00_A	0.53_B	0.25	32.34**
Rana utricularia (adults)		1	0.00	0.00	0.00	0.16	0.00	0.04	
		2	0.00	0.22	0.22	0.00	0.44	0.12	
		3	0.00	0.21	0.00	0.00	0.00	0.02	
	Total		0.00	0.15	0.05	0.04	0.15	0.06	
Rana utricularia (larvae)		1	0.11_A	1.18_B	0.92_B	0.00_A	0.00_A	0.35	17.39**
		2	0.37_A	5.25_B	2.63_B	0.24_A	0.44_A	1.34	76.57**
		3	0.00	0.00	0.00	0.00	0.23	0.02	
	Total		0.16_A	2.13	0.80_B	0.09_A	0.23_{AB}	0.54	90.53**

(Sheet 3 of 6)

Table A4 (Continued)

		Year	SOUTH POOL	MIDDLE POOL	EAST POOL	WEST POOL	GATLIN CANAL	Total	X^2
REPTILIA									
TESTUDINATA									
Chelydra serpentina		1	0.00	0.00	0.23	0.00	0.00	0.04	
		2	0.00_A	0.00_A	0.44_A	0.12_A	1.09	0.24	18.54**
		3	0.00	0.00	0.18	0.12	0.00	0.07	
	Total		0.00_A	0.00_{AB}	0.25_{BC}	0.09_{ABC}	0.38_C	0.12	16.70**
Kinosternon baurii		1	0.11	0.00	0.00	0.00	0.24	0.07	
		2	0.00	0.00	0.00	0.00	0.22	0.03	
		3	0.00	0.00	0.00	0.00	0.23	0.02	
	Total		0.03	0.00	0.00	0.00	0.23	0.04	
Kinosternon subrubrum		1	2.59	0.47_A	0.00_A	0.00_A	0.24_A	0.96	39.44**
		2	0.09	0.00	0.00	0.00	0.22	0.06	
		3	0.00	0.00	0.00	0.00	0.00	0.00	
	Total		0.78	0.15_A	0.00_A	0.00_A	0.15_A	0.29	39.77**
Pseudemys floridana		1	0.00	0.24	0.23	0.00	0.00	0.07	
		2	0.00	0.00	0.00	0.00	0.00	0.00	
		3	0.00	0.00	0.00	0.00	0100	0,00	
	Total		0.00	0.07	0.05	0.00	0.00	0.02	

(Sheet 4 of 6)

Table A4 (Continued)

		Year	SOUTH POOL	MIDDLE POOL	EAST POOL	WEST POOL	GATLIN CANAL	Total	X^2
Pseudemys nelsoni		1	0.11	0.00	0.00	0.00	0.00	0.04	
		2	0.00	0.00	0.00	0.00	0.00	0.00	
		3	0.00	0.00	0.00	0.00	0.00	0.00	
	Total		0.03	0.00	0.00	0.00	0.00	0.01	
Pseudemys scripta		1	0.00	0.00	0.00	0.00	0.00	0.00	
		2	0.09	0.00	0.00	0.00	0.00	0.03	
		3	0.00	0.00	0.00	0.00	0.00	0.00	
	Total		0.03	0.00	0.00	0.00	0.00	0.01	
Sternotherus odoratus		1	1.19_{AB}	0.71_{ABC}	0.00_{C}	0.49_{BC}	2.38_{A}	0.96	15.38**
		2	0.28_{A}	0.22_{A}	0.22_{A}	0.24_{A}	1.75	0.46	19.53**
		3	0.00_{A}	0.00_{AB}	0.09_{AB}	0.00_{A}	0.68_{B}	0.10	17.67**
	Total		0.44_{A}	0.29_{A}	0.10_{A}	0.22_{A}	1.59	0.45	47.40**
Trionyx ferox		1	0.11	0.00	0.00	0.00	0.00	0.04	
		2	0.00	0.00	0.00	0.00	0.00	0.00	
		3	0.00	0.00	0.00	0.00	0.00	0.00	
	Total		0.03	0.00	0.00	0.00	0.00	0.01	

(Sheet 5 of 6)

Table A4 (Concluded)

		Year	SOUTH POOL	MIDDLE POOL	EAST POOL	WEST POOL	GATLIN CANAL	Total	χ^2
SQUAMY									
Farancia abacura		1	0.11	0.00	0.00	0.00	0.00	0.04	
		2	0.09	0100	0.00	0.00	0.00	0.03	
		3	0.00	0.00	0.00	0.00	0.00	0.00	
	Total		0.06	0.00	0.00	0.00	0100	0.02	
Nerodia cyclopion		1	2.59_{AB}	1.65_{AB}	3.46_{A}	0.16_{C}	0.95_{BC}	1.81	20.95**
		2	0.09	0.22	0.66	0.12	0.44	0.24	
		3	0.08_{A}	0.00_{AB}	0.62_{B}	0.00_{A}	0.23_{AB}	0.22	12.15*
	Total		0.81_{A}	0.59_{A}	1.24_{A}	0.09	0.53_{A}	0.67	23.07**
Nerodia fasciata		1	0.00	0.00	0.00	0.00	0.24	0.04	
		2	0.09	0.22	0.00	0.24	0.00	0.12	
		3	0.00	0.21	0.00	0.00	0.23	0.05	
	Total		0.03	0.15	0.00	0.09	0.15	0.07	
Regina alleni		1	0.00	0.00	0.00	0.00	0.00	0.00	
		2	0.09	0.44	0.00	0.00	0.00	0.09	
		3	0.00	0.21	0.00	0.00	0.00	0.02	
	Total		0.03	0.22	0.00	0.00	0.00	0.04	

(Sheet 6 of 6)

Table A5

Comparisons of the distributions and mean relative densities of amphibians and reptiles at permanent shoreline sites as determined by herp-patrols. Site summaries include total herp-patrol hours and mean relative density (mean number/hour) for each species for each year. Chi-square values (χ^2) are provided only if significant between-site differences were detected (* = P<.05, ** = P<.01); site means with the same letter indicate no significant differences between sites (P>.025). See text for details.

	Year	SOUTH POOL	MIDDLE POOL	EAST POOL	WEST POOL	GATLIN CANAL	Total	χ^2
Herp-Patrol (total hours)	1	32.2	20.3	10.5	14.4	26.4	103.8	
	2	17.4	11.7	9.0	12.2	19.4	69.7	
	3	14.4	9.5	10.0	10.3	16.0	60.2	
Total		64.0	41.5	29.6	36.9	61.8	233.8	
AMPHIBIA								
CAUDATA								
Amphiuma means	1	0.00	0.00	0.00	0.00	0.00	0.00	
	2	0.00	0.00	0.00	0.00	0.05	0.01	
	3	0.00	0.00	0.00	0.00	0.00	0.00	
Total		0.00	0.00	0.00	0.00	0.02	0.00	
Siren lacertina	1	0.00	0.00	0.14	0.09	0.11	0.07	
	2	0.13	0.00	0.25	0.00	0.00	0.08	
	3	0.00_A	0.00_A	1.73	0.00_A	0.09_A	0.36	11.76*
Total		0.04	0.00	0.72	0.03	0.07	0.17	

(Sheet 1 of 6)

Table A5 (Continued)

	Year	SOUTH POOL	MIDDLE POOL	EAST POOL	WEST POOL	GATLIN CANAL	Total	X^2
ANURA								
Acris gryllus (adults)	1	16.17_A	5.67_{AB}	7.99_{AB}	0.00	0.57_B	6.11	14.79**
	2	15.88_A	6.55_{BC}	11.87_{AC}	0.24_B	0.65_{BC}	7.04	13.37**
	3	18.04_{AB}	6.07_B	21.90_A	0.00_C	1.56_{BC}	9.52	18.97**
Total		16.71_A	6.09_B	14.03_A	0.08	0.94_B	7.57	43.97**
Bufo terrestris (adults)	1	0.28	0.59	0.00	0.00	0.57	0.29	
	2	0.09	0.00	0.00	0.00	0.87	0.19	
	3	0.26	0.00	0.00	2.30	2.49	1.01	
Total		0.22	0.20	0.00	0.78	1.33	0.50	
Bufo terrestris (larvae)	1	0.00	0.00	0.00	0.00	0.00	0.00	
	2	0.00	0.00	0.00	0.00	0.11	0.02	
	3	0.00	0.00	0.00	0.00	0.00	0.00	
Total		0.00	0.00	0.00	0.00	0.04	0.01	
Gastrophryne carolinensis (adults)	1	0.00	0.13	0.00	3.93	0.13	0.85	
	2	0.36	0.00	0.00	5.27	0.22	1.17	
	3	0.14	0.25	0.00	7.55	0.07	1.60	
Total		0.16	0.13	0.00	5.59	0.14	1.21	

(Sheet 2 of 6)

Table A5 (Continued)

	Year	SOUTH POOL	MIDDLE POOL	EAST POOL	WEST POOL	GATLIN CANAL	Total	χ^2
Hyla cinerea (adults)	1	1.30_A	5.66_A	46.73_B	32.05_B	2.45_A	17.52	9.63*
	2	3.74	9.26	16.86	52.24	7.31	17.88	
	3	1.09	18.00	39.62	26.01	12.18	19.38	
Total		2.02_A	11.00_A	34.48_B	36.55_B	7.38_{AB}	18.27	12.10*
Hyla squirella (adults)	1	0.10	0.00	0.00	0.00	0.00	0.02	
	2	0.53	0.00	0.00	0.00	0.00	0.11	
	3	0.00	0.00	0.00	0.00	0.00	0.00	
Total		0.21	0.00	0.00	0.00	0.00	0.04	
Rana grylio (adults)	1	0.00	1.66	1.36	0.00	0.06	0.62	
	2	0.00	1.12	2.06	2.16	0.86	1.24	
	3	0.00_A	8.10_B	3.64_B	0.00_A	2.88_B	2.92	23.73**
Total		0.00_A	3.66_B	2.37_B	0.70_A	1.29_B	1.60	23.87**
Rana utricularia (adults)	1	1.30	1.10	5.50	1.77	1.05	2.13	
	2	2.27	2.95	2.46	3.72	2.93	2.87	
	3	2.21_{AB}	15.98	0.85_B	2.83_{AB}	2.41_A	4.86	14.48**
Total		1.92_A	6.73_{AB}	2.91_{AB}	2.76_{AB}	2.14_A	3.30	10.74*

(Sheet 3 of 6)

Table A5 (Continued)

	Year	SOUTH POOL	MIDDLE POOL	EAST POOL	WEST POOL	GATLIN CANAL	Total	X^2
REPTILIA								
CROCODILIA								
Alligator mississippiensis	1	0.00	0.12	0.00	0.00	0.00	0.03	
	2	0.00	0.00	0.00	0.00	0.12	0.02	
	3	0.00	0.00	0.00	0.00	0.08	0.02	
Total		0.00	0.04	0.00	0.00	0.07	0.02	
TESTUDINATA								
Chelydra serpentina	1	0.00	0.00	0.00	0.00	0.09	0.02	
	2	0.00	0.00	0.00	0.16	0.00	0.03	
	3	0.00	0.00	0.00	0.00	0.00	0.00	
Total		0.00	0.00	0.00	0.05	0.03	0.02	
Deirochelys reticularia	1	0.00	0.00	0.00	0.00	0.04	0.01	
	2	0.00	0.00	0.00	0.00	0.14	0.03	
	3	0.00	0.00	0.00	0.00	0.00	0.00	
Total		0.00	0.00	0.00	0.00	0.06	0.01	
Kinosternon baurii	1	0.03	0.03	0.00	0.00	0.00	0.01	
	2	0.00	0.00	0100	0.00	0.00	0.00	
	3	0.00	0.00	0.00	0.00	0.00	0.00	
Total		0.01	0.01	0.00	0.00	0.00	0.00	

(Sheet 4 of 6)

Table A5 (Continued)

		Year	SOUTH POOL	MIDDLE POOL	EAST POOL	WEST POOL	GATLIN CANAL	Total	X^2
Kinosternon subrubrum		1	0.14	0.00	0.00	0.00	0.06	0.04	
		2	0.14	0.00	0.00	0.00	0.03	0.03	
		3	0.11	0.00	0.00	0.00	0.00	0.02	
	Total		0.13	0.00	0.00	0.00	0.03	0.03	
Pseudemys floridana		1	1.51_{A}	1.02_{AB}	0.95_{BC}	0.11_{C}	0.83_{BA}	0.88	21.68**
		2	0.38_{AB}	0.00_{B}	0.77_{AC}	0.10_{AB}	1.49_{C}	0.55	13.61**
		3	0.14_{A}	0.35_{AB}	1.78_{C}	0.06_{A}	0.97_{BC}	0.66	11.30*
									23.08**
	Total		0.68_{A}	0.46_{A}	1.17_{A}	0.09	1.10_{A}	0.70	
Pseudemys nelsoni		1	0.14_{A}	0.25_{AB}	0.17_{A}	0.05_{A}	0.63_{B}	0.25	12.75*
		2	0.07_{A}	0.07_{A}	0.10_{A}	0.00_{A}	1.30	0.31	20.89**
		3	0.20	0.00	0.11	0.06	0.55	0.18	
	Total		0.14_{A}	0.11_{AB}	0.13_{AB}	0.04_{B}	0.82	0.25	31.56**
Sternotherus odoratus		1	6.21_{A}	8.69_{A}	5.36_{B}	2.44_{B}	6.61_{A}	5.86	18.63**
		2	5.45_{A}	5.48_{A}	0.65_{B}	2.48_{BC}	1.89_{C}	3.19	28.42**
		3	6.30_{A}	6.84_{A}	0.51_{B}	1.38_{B}	0.68_{B}	3.14	37.60**
	Total		5.99_{A}	7.02_{A}	2.15_{B}	2.10_{B}	3.03	4.07	73.87**
Trionyx ferox		1	0.22	0.05	0.15	0.00	0.07	0.10	
		2	0.00	0.00	0.00	0.00	0.00	0.00	
		3	0.00	0.00	0.00	0.00	0.05	0.01	
	Total		0.07	0.02	0.05	0.00	0.04	0.04	

(Sheet 5 of 6)

Table A5 (Concluded)

	Year	SOUTH POOL	MIDDLE POOL	EAST POOL	WEST POOL	GATLIN CANAL	Total	X^2
SQUAMATA								
Nerodia cyclopion	1	0.30	0.00	0.10	0.32	0.40	0.22	
	2	0.04	0.00	0.11	0.08	0.09	0.06	
	3	0.00	0.00	0.00	0.00	0.00	0.00	
Total		0.11	0.00	0.07	0.14	0.16	0.10	
Nerodia fasciata	1	0.00	0.00	0.00	0.00	0.38	0.07	
	2	0.00	0.00	0.00	0.00	0.16	0.03	
	3	0.00	0.00	0.00	0.00	0.06	0.01	
Total		0.00	0.00	0.00	0.00	0.20	0.04	

(Sheet 6 of 6)

Table A6

Comparisons of the mean relative densities (number calling/hour) of the six most common species of frogs encountered on herp-patrols at permanent shoreline sites on Lake Conway during the three-year study. Only the breeding seasons are included in the analysis (April - September for all species except *Rana utricularia*, which called from December-June). Chi-square values (χ^2) are provided only if significant between-site differnces were detected (* = $P<.05$, ** = $P<.01$); site means with the same letter were not significantly different ($P>.025$).

	Year	SOUTH POOL	MIDDLE POOL	EAST POOL	WEST POOL	GATLIN CANAL	Total	χ^2
Acris gryllus	1	29.33_A	11.20_{AB}	15.31_A	0.00_C	1.10_{CB}	11.39	22.34**
	2	29.53_A	12.55_{AB}	20.31_A	0.45_B	1.25_B	12.82	18.69**
	3	35.84_A	9.66_B	41.72_A	0.00_C	3.11_{BC}	18.07	31.41**
Total		31.57_A	11.14_B	25.78_A	0.15	1.82_B	14.09	69.83**
Bufo terrestris	1	0.57	1.17	0.00	0.00	1.09	0.57	
	2	0.18	0.00	0.00	0.00	1.67	0.37	
	3	0.28	0.00	0.00	4.60	4.98	1.05	
Total		0.34	0.39	0.00	1.53	2.58	0.97	
Gastrophryne carolinensis	1	0.00	0.26	0.00	7.87	0.26	1.68	
	2	0.70_{AB}	0.00_B	0.00_B	10.11_A	0.42_B	2.25	9.52*
	3	0.28	0.50	0.00	15.10	0.14	3.20	
Total		0.32_A	0.25_A	0.00_A	11.03	0.27_A	2.37	14.69**

(Sheet 1 of 2)

Table A6 (Concluded)

		Year	SOUTH POOL	MIDDLE POOL	EAST POOL	WEST POOL	GATLIN CANAL	TOTAL	χ^2
Hyla cinerea		1	2.59_{A}	11.33_{A}	89.58_{B}	63.97_{B}	4.70_{A}	34.43	23.94**
		2	7.17^{A}	17.74^{A}	32.32^{B}	100.13^{B}	13.95^{A}	34.26	
		3	2.18_{A}	36.00_{AB}	79.25_{B}	52.03_{B}	24.36_{B}	38.76	13.06*
	Total		3.98_{A}	21.69_{AB}	67.05_{C}	72.04_{C}	14.34_{B}	35.82	34.59**
Rana grylio		1	0.00_{A}	2.77	2.62_{A}	0.00_{A}	0.08_{A}	1.09	9.46*
		2	0.00	2.16	3.96	4.14	1.66	2.38	
		3	0.00_{A}	15.43_{C}	7.27_{BC}	0.00_{A}	5.05_{B}	5.55	31.47**
	Total		0.00_{A}	6.79_{B}	4.62_{B}	1.38_{A}	2.26_{B}	3.01	33.76**
Rana utricularia		1	2.07	1.76	9.04	2.53	1.54	3.35	
		2	4.01	3.96	4.36	5.92	3.69	4.39	
		3	3.78	16.87	0.33	4.52	2.75	5.65	
	Total		3.19	7.30	4.47	4.28	2.66	4.39	

(Sheet 2 of 2)

APPENDIX B

SUMMARY OF DETECTED ANNUAL CHANGES IN THE ECOLOGY OF THE 30 SPECIES OF AMPHIBIANS AND REPTILES INHABITING LAKE CONWAY, AND AN ASSESSMENT OF THE CAUSATIVE AGENTS. Statistically significant changes in an ecological parameter are indicated by an asterisk, biologically meaningful changes are without an asterisk. Causative agents were assigned a major (capitalized) of minor (lower case) role based on the available evidence. The labeled causative agents are: BM = boat mortality, D = density, DR = destruction or removal of individuals, IE = investigators, SD = shoreline development, U = unknown, W = weather, WA = white amur, WL = water level. Certain critical life history traits of the species also are summarized including: sample size, habitat use (L = littoral zone, O = open water, T = terrestrial; order of habitats indicate their descending frequency of use by the species), trophic position (C = carnivore, H = herbivore, O = omnivore) average adult body size (1 = 1-10g.. 2 = 11-100g., 3 = 101-1000g., 4 = 1001-10,000g., 5 = > 10,000g.), sexual dimorphism (larger sex is listed first if dimorphism in adult body size exists, nondimorphic species indicated by an equal sign; F = female, M = male), and years to maturity based on the present report or the literature (? indicates average age at maturity unknown or poorly known; if sexual dimorphism exists average age at maturity of larger sex listed first).

	ECOLOGICAL PARAMETERS									LIFE-HISTORY TRAITS					
	Habitat		Activity		Demography										
	Litt.	O.W.	Seas.	Move.	Struc.	Density.	Food	Growth	Repro.	Sample Size	Habitat Use	Trophic position	Adult body size	Sexual Dimorphism	Years to Maturity
AMPHIBIA															
CAUDATA															
Amphiuma means					*U,ie wl	*SD,IE U,ml	*D			383	L-T	C	3	-	3-4
Eurycea quadridigitata										2	L-T	C	1	-	1
Pseudobranchus striatus										2	L	C	1	F/M	1/1
Siren lacertina		*WA			*U	*SD,IE wl				238	L-O	O	3	M/F	3/3
ANURA															
Acris gryllus			W			SD				1,364	T-L	C	1	F/M	1/1
Bufo terrestris			W							809	T-L	C	2	F/M	1/1
Gastrophryne carolinensis			W							174	T-L	C	1	F/M	1/1
Hyla cinerea			W			*SD				2,646	L-T	C	1	F/M	1/1
Hyla femoralis						SD				4	T-L	C	1	F/M	1
Hyla squirella						*SD				17	T-L	C	1	F/M	1/1
Rana grylio						*SD				293	L-T	C	2	-	1-2?
Rana utricularia			W			*SD				377	T-L	C	2	-	1
REPTILIA															
CROCODILIA															
Alligator mississippiensis					DR,SD bm	SD,DR wl,bm				285	L-O-T	C	5	M/F	9/5
TESTUDINATA															
Chelydra serpentina						*U				21	L-T-O	C	4	M/F	?
Chrysemys picta										1	L-O-T	C	3	F/M	5/3
Deirochelys reticularia										3	L-T-O	C	3	F/M	?
Kinosternon baurii										14	L-T-O	C	3	F/M	?
Kinosternon subrubrum		*WA				*SD,wa				90	L-O-T	C	3	M/F	5/7
Pseudemys floridana		*WA			*SD,BN wa	*SD,bm, wa	WA			902	O-L-T	H	4	F/M	16/5
Pseudemys nelsoni					SD,wl	WA				266	L-O-T	H	4	F/M	8/5?
Pseudemys scripta										3	L-O-T	O	3	F/M	6/3
Sternotherus odoratus		*WA	W	*IE	*IE,U	*SD,IE wa,bm	*WA			3,523	O-L-T	C	2	F/M	3/3
Trionyx ferox										50	O-L-T	C	4	F/M	?
SQUAMATA															
Coluber constrictor										2	T-L	C	2	F/M	2/2
Farancia abacura										6	L-T	C	4	F/M	3/2
Nerodia cyclopion						*SD,DR ie,wl				233	L-T-O	C	4	F/M	3/2
Nerodia fasciata										46	L-T-O	C	3	F/M	3/2
Regina alleni										7	L-T	C	2	F/M	2/2?
Thamnophis sauritus										6	L-T	C	2	F/M	2/2?
Thamnophis sirtalis										2	T-L	C	2	F/M	2/2?

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